Mr. Rothberg

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TERSHED PROTECTION AND FLOOD PREVENTION

MUDDY FORK OF SILVER CREEK WATERSHED

Clark, Floyd and Washington Counties, Indiana

OUR SOIL ★ OUR STRENGTH

WATERSHED WORK PLAN

MUDDY FORK OF SILVER CREEK WATERSHED

Clark, Floyd, and Washington Counties, Indiana

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666) as amended.

Prepared by:

Clark County Soil and Water Conservation District
Floyd County Soil and Water Conservation District
Washington County Soil and Water Conservation District
Town of New Providence, Inc.

With Assistance by:

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MUDDY FORK OF SILVER CREEK WATERSHED

SUMMARY OF THE PLAN

The Muddy Fork of Silver Creek Watershed occupies an area of 42,642 acres in Clark, Floyd, and Washington Counties, in southeastern Indiana.

The project sponsors are the Clark County, Floyd County, and the Washington County Soil and Water Conservation Districts, and the Town of New Providence, more commonly known as Borden, Indiana. The sponsors and watershed residents have long recognized the problems of floodwater damage to crops, roads, railroad, residential areas, and land and water shortages that occur almost annually. Their efforts to cope with these problems are incorporated into this watershed work plan.

Floods occur on the average of three times per year during the cropping season. Two storms--June 13 and 22, 1960, resulted in over $50,000 damage to the Town of Borden. Highway 60 was closed for a short period. Many houses had two feet of water on the floors. The cabinet factory was shut down for a day when floodwater rose to several inches in the boiler room. Borden has no central water system, and the private wells were made unusable by the flood of muddy water. The current swept a torrent of debris along the flood plain. Many crops were destroyed and had to be replanted. Railroad ballast was washed out and rails left hanging. Rail traffic has been suspended on several other occasions.

Vegetable growing offers an added source of income to low income farms in the area. It is estimated only 53 acres of vegetables are now grown due to the flood risk involved. This watershed is located near the

canning factory at Austin, Indiana, and the fresh vegetable market in Louisville, Kentucky. Therefore, a good market exists for vegetables produced in this area.

Under present conditions, 3,180 acres are flooded by the 5-year storms. With project, this size storm will flood 360 acres. The 3-year flood will not cause future overbank flow. The proposed works of improvement will reduce flood damages 90%. Damage is reduced to a five-year cropping season level in reaches V through VIII and 3 to 5 year level in reaches II through IV. Flooding on all season basis in the Town of Borden will be less frequent than once in ten years. The 100-year frequency storm would be approximately two feet above bank full with very little associated damage. Urban damage will be reduced 94% with project. The eight structures will regulate 36% of the total watershed drainage area. The reduction of flooding during the cropping season of April through November will permit the flood plain acres to be used for high value vegetable crops, with less acreage devoted to surplus crops. The total average annual floodwater damage is estimated to be $91,850. Crop and pasture damage is $53,250 or 58%.

There are 96 farms represented in the benefited area of 4,718 acres that will receive direct flood reduction benefits. There are approximately 322 farms in the watershed. There are 74 district cooperators of which 48 have basic farm plans. Land ownership is private except for 3,840 acres of state owned woodland. Approximately 70% of the total watershed area is woodland. Practically all the cropland is located within the flood plain.

The Indiana Flood Control and Water Resources Commission has constructed a flood prevention and recreation structure with a 192 acre conservation pool at srtucture site No. 8, as shown on the project map. About 14 inches of runoff from the drainage area is being stored for flood prevention. One half c. f. s. will be released for low flow regulation and water quality control. Approximately 600 acres surrounding this lake has been purchased for access and basic facilities. The Indiana Department of Conservation will install the basic recreation facilities. This public recreational development is planned to meet the needs of this area for public recreation. This development will be accomplished with 100% state funds and the lake will be referred to as "Deams Lake" throughout this plan.

The planned works of improvement consists of the following measures: (1) land treatment-devoting land to its proper use and conservation treatment needed for sustained agricultural production, (2) installation of three floodwater retarding structures and four multiple purpose structures, one for flood prevention and municipal water supply, and three for flood prevention and recreational development, and (3) 12.5 miles of channel improvement. The planned works of improvement will be installed in a five year period.

The estimated total annual benefits from the proposed structural program is $148,585, including: (1) damage reduction of $74,768, (2) more intensive use of present cropland of $18,477, (3) changed land use benefit of $4,935, (4) local secondary benefit of $14,390, (5) recreational benefit of $17,400, (6) water supply benefit of $8,060, and (7) redevelopment benefit of $10,555. The total annual cost, including operation and maintenance for the structural measures, is $114,074,

as compared to the annual benefits of $148,585, which gives a benefit cost ratio of 1.3 to 1.

The project costs are estimated to be $2,561,050. This includes $314,980 for land treatment measures and $2,246,070 for the structural measures. The P.L. 566 share of the cost is $62,730 for accelerating technical assistance for land treatment measures, and $1,766,240 for the cost of structural measures allocated to flood prevention. Other than P.L. 566 costs include $252,250 for the installation of land treatment measures, $214,810 construction cost allocated to non-agricultural water management, $59,560 installation services, $30,680 for administration of contracts, $144,780 for land easements and rights-of-way and $30,000 for overhead.

In addition to these project costs, the local people have invested a total of $846,350 in Soil and Water Conservation practices as shown in Table 1A. The capitalized value of the operation and maintenance of the project during project evaluation period is $620,788.

In consideration of the overall cost sharing for Soil and Water Conservation Development, the following is significant: The total local contribution is $1,946,968. The total P.L. 566 contribution is $1,766,240.

Maintenance of land treatment measures will be carried out by the land owners involved. The proposed conservancy district, now being formed will be responsible for the operation and maintenance of the planned structural measures except structure No. 1. The Town of Borden will be responsible for the O&M of structure No. 1 and the water supply features.

DESCRIPTION OF THE WATERSHED

Physical Data

The Muddy Fork of Silver Creek Watershed is located in Clark, Floyd, and Washington Counties in southeastern Indiana. The watershed drainage area is 66.67 square miles or 42,642 acres, situated about 15 miles northwest of Louisville, Kentucky. There are 39,997 acres in Clark County, 1045 acres in Floyd County, and 1600 acres in Washington County.

Muddy Fork of Silver Creek rises in the steep "Knobstone" uplands about three miles northwest of Borden. It is joined by the following major tributaries in its southeasterly course; Packwood Branch, Souder's Branch, Fordyce Branch, Dry Fork, Koetter Branch, Persimmon Run, Money Branch, Big Run, Turkey Run, and Elk Run.

Muddy Fork joins Silver Creek just northeast of Speed, Indiana, and Silver Creek flows into the Ohio River about 12 miles south of this confluence.

Muddy Fork of Silver Creek Watershed is about 15 miles long and has an average width of about 4.5 miles. The maximum elevation in the uplands is about 980 feet above sea level while the elevation at the outlet is about 437 feet above sea level.

The western half of the drainage area is in the Norman Upland physiographic unit of Indiana. This area is characterized by steep hills, narrow ridge tops, and relatively narrow flood plains. The eastern half of the drainage area is in the Scottsburg lowland. This area is glaciated and consists of low, gently rolling uplands and wide flood plains.

The watershed is located in Land Resource Regions M and N. 1/ Land Resource Region M, the Central Feed Grains and Livestock Region, is represented by Major Land Resource Area 114 - the Southern Illinois and Indiana Thin Loess and Till Plain. The upper watershed margin falls within the eastern extremity of this major area and the soils are Zanesville and Wellston silt loams. Land Resource Region N - the East and Central General Farming and Forest Region, is represented by Major Land Resource Area 120. This area - the Kentucky and Indiana Sandstone and Shale Hills and Valleys - is represented by Muskingum, Wellston valley walls and Stendal, Philo, and Pope bottomlands. Along the valley walls and in the flood plains in the lower parts of the watershed glacial drift and lacustrine soils are found.

The steep, shallow-mantled hillsides are nearly all wooded. Lack of moisture storage space on these hillsides causes rapid and high runoff of rainfall.

Limestone, which underlies the lower portion of the watershed, is mined commercially in the vicinity of Speed, Indiana.

Water supply for the watershed has been a critical factor for many years. The shallow soils and dense bedrock are ill suited to holding water, and wells are not generally satisfactory. Springs exist along the steep valley walls, but the flow of water is not consistent. A few farm ponds and recreation water impoundments are located in the watershed. The Town of Borden obtains its water from wells which are not

1/ Reference is made to "Atlas of River Basins of the United States," prepared by the U. S. Department of Agriculture, Soil Conservation Service, June 1963.

adequate for industrial or urban development and growth.

Mean temperatures range from 33 degrees in January to 77 degrees in July. The recorded extremes are 111 degrees above zero and 26 degrees below zero. The average date of the last spring freeze is May 2, while the first fall freeze is October 6, providing a 157 day average without freezing temperatures. Mean annual precipitation is 42.7 inches. The more intense rains usually come in April, May, and June. The minimum annual rainfall recorded at the Henryville station, about five miles north of the watershed, is 31.2 inches while the maximum is 59.6 inches.

Economic Data

The U. S. Census of Agriculture, 1959, for Clark County, shows the average size farm to be 177 acres with an average value for land and buildings of $160 per acre. General farming is practiced in the watershed with the major farm income derived from the sale of livestock, with hogs, cattle, and poultry leading in that order.

Principle crops grown are corn, soybeans, small grain, and hay. A small amount of vegetables is grown for the canning factory at Austin, Indiana. There are approximately 322 farms in the watershed averaging in size about 120 acres. About 25% are tenant operated. Approximately 60% of the farm operators work off the farm with an estimated 50% of these having an income exceeding the value of agricultural products sold. According to the 1959 census, 16% of the commercial farms have sales of less than $2500; 34% less than $5000. There are 74 cooperators and 48 basic farm plans within the watershed.

Land ownership is private except for 3,740 acres in the northern part of the watershed which is part of the Clark State Forest. State

ownership is nearly all consolidated in large blocks.

Most of the upland slopes are wooded. The valley is relatively level, being quite narrow at the upper end, but gradually widening until it averages about a mile in width for the greater part of its length. Stendal is the dominant bottomland soil.

Present land use conditions and future conditions, as anticipated after the project is installed, are shown in the following table. Present conditions are shown as "Without Project," future conditions are "With Project."

Land Use - Muddy Fork of Silver Creek Watershed

	Without Project			With Project		
	Floodpl.	Upland	Total	Floodpl.	Upland	Total
	Acres					
Cropland	3,343	5,115	8,458	3,503	4,413	7,916
Grassland	278	1,922	2,200	278	2,490	2,768
Woodland	614	29,172	29,786	454	29,157	29,611
Other 1/	483	1,715	2,198	483	1,864	2,347
Total	4,718	37,924	42,642	4,718	37,924	42,642

1/ Includes farmsteads, urban, roads, sediment pools, and structural sites.

There are four small towns within the watershed. Borden and Carwood are located in the upper part of the floodplain. Speed is located at the outlet of Muddy Fork, and Bennettsville in the southeast portion of the watershed. Borden and Speed, each with a population of approximately 300, support a small industry. Located at Borden is the Borden Cabinet

Corporation, employing 264, and at Speed, the Louisville Cement Company, employing 554.

A good county road system and Indiana State Highway 60 provide easy access to any part of the watershed. The Monon Railroad extends the full length of the watershed and follows the floodplain for the major part of the distance.

WATERSHED PROBLEMS

Floodwater Damage

High intensity rainstorms result in rapid runoff from the steep hillsides. This situation results in high peaks causing heavy damage to crops, roads, urban areas, and to the land. Floods occur on the average of three times per year during the cropping season. Borden suffers severe damage. Two storms--June 13 and 22, 1960, resulted in over $50,000 damage to the town. Highway 60 was closed for a short period. Many houses had two feet of water on the floors. The cabinet factory was shut down when floodwater rose to several inches in the boiler room. More than fifty homes at Borden were damaged. The rampaging waters buckled a 12 inch foundation wall and washed out a cavern beneath the Lawson Grocery. Borden has no central water system, and the private wells were made unusable by the flood of muddy water. The current swept a torrent of debris along a mile course from the center of town and paralleling both sides of State Road 60.

At Carwood, five miles east of Borden, three houses and a house trailer were flooded. Water was waist deep and people had to be rescued by boat.

As described by some old timers in Borden, this flood was the worst they could recall. As valued from the hydrologic studies, the June 1960, flood is a hundred year frequency storm. Floods of lesser magnitude have caused damage to residential, business, and industrial property, as well as, crops. Some of the recent floods of record are January 2, 1956, April 1957, January 21, 1959, and March 2-13, 1964.

Frequent spring floods delay land preparation and planting on 4,718 acres of flood plain land. Replanting of crops, in many instances, is necessary. These spring floods very often result in broken, uneven stands, increased cost of production, and greatly reduced yields. Vegetable production on this land is too much of a risk. Only a small acreage is now grown. The watershed, being located near the canning factory at Austin and the fresh vegetable market in Louisville, Kentucky, has great potential for vegetable production.

The total average annual floodwater damage is estimated to be $91,850, as shown in Table 5. The average annual floodwater damage to crops and pasture is $53,250. Damage to the network of roads and to the railroad is estimated at $13,975 annually. Average annual damage in Borden and to scattered residential property along the valley is $9,000. Other agricultural damage, mostly to farm fence, is estimated at $5,093 annually.

Indirect damages include: disruption of traffic; depreciation in land values caused by frequent overflow; increased cost required to carry on normal operations during flood periods; and increased depreciation to farm machinery as a result of working over scour areas or handling dusty crops during harvest.

Sediment Damage

Sediment is found in the watershed flood plains and channels in the form of narrow natural levees and channel deposits. The overbank levee deposits are insufficient in extent to merit consideration. The within-bank deposits fluctuate very little in extent or depth. The aggravated flooding brought about by these deposits is included in the overbank flooding damages evaluated in this plan as they are considered inseparable.

Erosion Damage

Erosion occurs in the upland areas of the watershed. On the ridgetops sheet and gully erosion has left its mark. Areas once in crops have been diverted to less erosive land use. Other areas have grown idle and now are covered with broom sedge, sassafras and sumach brush. Fields still in crops are subject to severe sheet and gully erosion. The most severe erosion takes place on the unprotected ridge top slope breaks. Both gully and sheet erosion are to be found there.

A high percentage of the steep valley slopes are in timber. Sheet and gully erosion occurs in this area. Although the rate of erosion on the steep land is much less than that on the ridge tops and lower valley slopes, the soil is much more shallow and there is less to lose. Woodland grazing, inadequate management practices and insufficient replanting have increased the erosion hazard on these steep woodlands.

Sheet and gully erosion takes place on the lower valley walls and in the more gently sloping downstream uplands. Much of this land is cropped and conservation practices are necessary to reduce this erosion.

Flood plain erosion, in the form of scour, is responsible for significant erosion damage in the watershed. It is estimated that scour causes

an annual incremental loss of productivity of from 19% to 42% on 7.1 acres. This amounts to an equivalent of 2.1 acres damaged 100% annually or 105 acres that would be damaged during the project life with no controls. This amounts to an average annual damage of $2,182.

Problems Relating to Water Management

Farm drainage facilities are needed on approximately 25% of the flood plain. Most drainageways are of adequate capacity to serve as outlets for drainage systems. The land treatment portion of this plan is developed to provide adequate arrangements to meet these flood plain needs.

All potentials of multiple use of the floodwater retarding structures, by incorporating permanent storage, have been given due consideration by the sponsoring local organization.

As one of the objectives of the project, the local leadership has stressed the need for permanent water storage for municipal water supply and recreation. A recreational lake to be located within the Clark State Forest has long been an objective of the state, as well as, that of local civic groups. This watershed lies within 30 miles of the tri-city area of Louisville, Kentucky; New Albany and Jeffersonville, Indiana; making it ideal for recreational development and industrial expansion. Water for recreational use would be within a 50-mile range of a potential user day from a population of over 500,000.

PROJECTS OF OTHER AGENCIES

The Indiana Flood Control and Water Resources Commission is, at present, constructing "Deams Dam" on Big Run tributary for the purpose of public recreation, flood control and low flow regulation for water

quality control. This structure is planned as an integral part of this over-all watershed work plan. Big Run tributary enters Muddy Fork approximately one mile below Carwood. Full coordination with the state is being carried out in developing the flood protection aspects of the watershed. The effects, with the Big Run structure (Deams Lake) in place, were considered in the evaluation of the works of improvement included in this plan. This structure and reservoir area are being developed by the state in accordance with their long range program which will provide for the most beneficial use of reservoir lands, and fish and wildlife resources and will afford an opportunity for outdoor activities for the general public. Deams Lake will have a normal surface area of 192 acres for public recreation.

BASIS FOR PROJECT FORMULATION

The economy of the Muddy Fork of Silver Creek Watershed is primarily agricultural. The watershed is in an area which is generally considered to be under-developed. The average per capita income is low. The flooding problems on Muddy Fork and to the Town of Borden (population about 300) have contributed to this. The number of farms in Clark County has decreased 19% from 1954 to 1959, and from general observation, this would also apply to the Muddy Fork Watershed area. The average age of the farmers in the area is about 52 years.

As shown in the over-all economic development plan for Clark County, the unemployed workers are about 6% of the total population.

Urbanization along Indiana State Highway 60, which spans the entire length of the watershed, is growing rapidly with people who commute to work in Louisville, Kentucky; New Albany and Jeffersonville, Indiana.

A large area along this route has been zoned by the County Planning Commission for residential use and is building at a rapid rate. It is expected that the population in this area will double in the next 20 years.

Wells are being put down with an increasing number that fail to produce an adequate water supply. In the fall drought of 1963 several wells went dry, and the sale of water to outlying areas had to be stopped. Water supply for this area along state route #60 and for the Town of Borden is urgent. A recent test conducted by the Clark County Board of Health, of 35 residential water supplies of the residents in the Town of Borden showed that 31 of these were contaminated and unsafe for human consumption. The only other water supply, other than surface water storage, is the Ohio River which is more than twenty miles away.

Except for boating on the Ohio River, water based recreation in this area is preactically non-existant, with the closest lakes of any size being approximately 50 miles away.

Farming in the watershed is generally confined to the bottomland. Due to topography of the watershed, there is very little upland suitable for cultivation. This places a considerably greater emphasis on flood protection of the flood plain. Vegetable growing is well adapted to the bottomland soils, but the flood hazard has discouraged the production of these crops. With more than one half million people living within a fifty mile radius of the watershed, the market potential is almost unlimited.

The sponsoring local organization desires a high degree of protection to the extent that vegetable growing can be carried out on most of the flood plain land. They feel that a frequency of no more than one

flood in three-five years in the cropping season will permit this, as well as, reduce their present agricultural loss to a minimum. They request an adequate water supply in the way of multi-purpose storage in floodwater retarding Structure #1 to meet the present and future expanded growth for the Town of Borden and the outlying area along State Highway 60.

The land treatment goals, as set out in this plan, are expected to meet the needs of the project, and it is expected that these measures can be carried out in the installation period of the project.

Two alternate levels of protection for the main flood plain were studied. The first was to provide a five year cropping season frequency to the main flood plain. This alternate resulted in such a large channel that the peak discharges into Silver Creek would be greater than under present conditions. Therefore, the level of protection in the lower part of the flood plain was reduced to a three year level of protection.

The drainage pattern of the watershed and the location of existing improvements prevent the use of larger floodwater retarding structures. Thirty five structure sites were investigated, with sixteen of these being studied. All but eight of the sites were small in area controlled and relatively high in cost. Deams Lake, one the eight sites, is being built with 100% state funds for recreation and flood prevention. This structure is necessary to realize the full benefits of the project.

Many alternate routes for the channel were studied. The planned route appears to be the most desirable considering good design practices, existing facilities, the desires of the local people, and costs.

In the early stages of development of this watershed several alternate proposals for recreation and other multipurpose uses were studied.

The local sponsors put forth considerable effort to develop interest and sponsorship for multiple use of each site. The sponsors interested the state in developing the site of Deams Lake into a public recreational area. Every consideration was given to the public use and development of the other sites in the watershed and no other sponsor was found to be interested in public recreation on these sites.

To fully utilize the natural potential offered by the area surrounding structures Nos. 4, 6 and 7, these are to be developed as multiple purpose structures for flood prevention and recreation. This recreation is for organized groups and conservation clubs.

The Town of Borden plans to use Structure No. 1 as a town and community water supply including the installation of necessary filtration, pumping and distribution facilities. This structure will impound 250 acre-feet of permanent water for the town and community water supply. A private engineering firm was employed by the Town of Borden to plan and coordinate this development as an integral part of this watershed work plan.

Structure No. 4, with permanent impoundment providing a 30 acre lake, is being sponsored and the additional storage paid for by an organized group for residential development and recreation. Not only will this serve a large number of people, but it enhances the natural resource of this site.

Structure No. 6, with the addition of permanent storage creating a 21 acre lake, is to be used for recreation. The Wood Township Conservation Club will develop this site for use by the club. This club is a local organization with a membership of about 30. This lake will provide fishing, boating, swimming, and other water based recreation. Camping facilities and other improvements will be added as needed by the conservation club.

Structure site No. 7 will include permanent storage. This additional storage, above that required for flood prevention, will provide a 25 acre lake. This impoundment will provide more utilization of this site and will be an asset to the area. The conservancy district will finance and operate this structure in the interest of the community for water oriented recreation.

The multiple purpose structures, as described, show that the intent of this proposed watershed development is to utilize the floodwater retarding sites to the fullest extent that local money is available. The proposed reservoirs of this project are favorable for the purposes, as mentioned, because of their proximity to population centers and easy accessibility by Interstate 65 which crosses the lower portion of the watershed and by State Highway 60.

The demand for outdoor recreation is greater than present facilities can handle due to the influx of people in the area.

The topography of the area is well suited for water detention and storage. The preliminary site investigations indicate the water holding potential to be satisfactory in all of the sites.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The initial step in flood prevention and watershed protection is the development of an effective land treatment program. It is necessary to increase the amount and rate of measures being installed to bring about the desired results. There are 74 cooperators and a total of 48 basic plans serviced within the watershed.

It is estimated that the application of the proposed land treatment measures will reduce damages in the benefited area by approximately four percent.

Land treatment measures to be applied on the cropland of the watershed will be (1) conservation cropping systems, (2) contour farming, (3) cover cropping, (4) crop residue use, (5) diversions, (6) grade stabilization structures, (7) grass waterways, (8) minimum tillage, (9) plow plant, (10) terraces, and (11) tile drains.

Land treatment measures to be applied on the grassland are as follows. (1) pasture planting, (2) grade stabilization structures, and (3) farm ponds.

Land treatment measures to be applied on idle and miscellaneous land are primarily grade stabilization structures.

State lands in the watershed include 3,740 acres within the Clark State Forest. The forestry program includes 3,740 acres of improved forestry practices and 1,000 acres of cultural practices to be installed on these lands.

Land treatment measures for woodland to reduce soil erosion and water runoff will be (1) livestock exclusion, (2) improved forestry practices, and (3) cultural practices.

Structural Measures

The structural measures included in this plan, as shown on the Project Map, consist of three floodwater retarding structures, four multi-purpose structures, and 12.5 miles of channel improvement.

The seven structures will be earth fill dams with principal spillways of a reinforced concrete inlet and a reinforced concrete pipe conduit.

Each of the structures has a two stage inlet to the principal spillway. A vegetated earth emergency spillway will be constructed on structures 4 and 6. The emergency spillways of structure numbers 1, 2, 3, 5, and 7 will be cut into Borden Shale. These structures are designed to temporarily detain 3,717 acre-feet of floodwater which is equivalent to 3.43 inches of runoff from the drainage area above the structures. These seven structures, plus Deams Lake, control 36% of the total watershed drainage area. Each structure contains a five year cropping season frequency runoff with moisture condition II$\frac{1}{2}$ between the low and high stage inlets.

A slide headgate at the bottom of the inlet and a pipe conduit to the reservoir area is planned on each structure. This gated outlet will allow for complete drawdown of the reservoir or sediment pool. The reservoir can be drained for health and safety reasons or to make repairs on the structure. This facility will also allow the normal stream flow to pass through the dam during construction. The dam can be constructed in a more efficient manner and the borrow from the reservoir area can be more fully utilized.

Geologic and soil conditions at the structure sites appear satisfactory. Sufficient and suitable borrow material is available. Prior to design, detailed geologic investigations and soil mechanic analyses will be made for each site. Sediment storage requirements, as computed, are believed to be adequate for final design purposes.

The three floodwater retarding structures (numbers 2, 3, and 5) will contain a sediment pool capacity of 125 acre-feet with a total surface area of 23 acres. The sediment pools are designed for a 50-year life. The average depth of the sediment pools is about five feet, and they are

expected to hold water. The total installation cost of the floodwater retarding structures is estimated to be $710,630. Figure 1 is a typical drawing of these structures. The cost distribution is given in Table 2. Design data for each structure is given in Table 3.

Multi-purpose structure No. 1 will provide storage for flood prevention and municipal water supply. To supply the Town of Borden and nearby residences, 250 acre-feet of water storage is planned. The total installation cost of structure No. 1 is estimated to be $229,700. Details of the cost distribution and cost sharing can be found in Tables 2 and 2A. Design details are shown in Table 3. Figure 1 is a typical section of this structure. A pumping station is planned on the east side of the reservoir area with a pipe line to the treatment plant. The installation cost of the raw water pumping station, pipe line, and appurtenances is estimated at $12,400. The cost distribution is shown in Table 2.

Structure No. 4 is planned for multi-purpose flood prevention and recreation. The conservation pool of this structure will have a surface area of 30 acres. The lake formed by this structure will be the central feature of a residential development. It will provide water based recreation and add greatly to the asthetic value of the development. The total estimated installation cost of this structure is $163,980. The basic recreation facilities planned are hard surface roads, a boat ramp, and docking facilities. The estimated installation cost of these facilities is $57,280.

The Wood Township Conservation Club will utilize multi-purpose structure No. 6 for water based recreation. The surface area of the conservation pool will be 21 acres. This structure is for recreation and flood

prevention. This structure is estimated to cost $150,130 for the total installation. The total installation cost for recreation facilities is estimated at $31,120. These facilities planned are an access road, a boat ramp, a shelter house, picnic tables, and pit toilets.

Structure No. 7 is planned to provide flood storage and a conservation pool. The conservation pool is to be used for recreation. This structure is planned to have a surface area of 25 acres and a volume of 127 acre-feet in the conservation pool. The total installation cost of structure No. 7 is estimated at be $167,110. The recreation facilities for this structure include an access road with parking area, picnicing area with tables, pit toilets, and a boat ramp. The estimated installation cost of these facilities is $18,270, as shown in Table 2.

The cost distribution and cost sharing on structure Nos. 4, 6, and 7 are shown in Tables 2 and 2A. Table 3 gives design details of these structures. A typical drawing is shown in Figure 1.

The channel improvement in Reach I is to provide an outlet for the channel above. This portion of the channel will serve as a transition to Silver Creek. The outlet will be at the present location which is a short distance above the Louisville Cement Company dam on Silver Creek. Reach I will follow the existing channel. The existing channel will be cleared, snagged, and seeded only from the outlet to the U. S. Highway 31 bridge where excavation will start.

Reaches II, III, and the lower part of IV are designed to carry the three year frequency cropping season storm flow. The planned channel in these reaches follows the general route of the existing channel; however, major straightening is necessary in some areas.

The upper part of Reach IV and Reaches V and VI are designed to carry the five-year frequency cropping season storm flow. Some major straightening is required in Reach V below Carwood. The channel above Carwood will have only minor realignment.

The channel improvement on Elk Run is designed to carry the three year frequency cropping season storm flow. Minor realignment is planned with some enlargement from the outlet into Muddy Fork of Silver Creek to a point about 600 feet above the first county road over Elk Run. The improvement planned includes clearing, snagging, and seeding of the banks from the point where excavation stops to the west edge of the woods, approximately 700 feet downstream from State Road 60.

All of the channel improvement is for flood prevention only. The design features of the channel are given in Table 3A. Figure 2 represents typical channel sections. The total estimated installation cost of channel improvement is $705,450. The cost distribution may be found in Table 2.

EXPLANATION OF INSTALLATION COSTS

Project Costs

The estimated installation cost for all land treatment measures is $314,980. Technical assistance will be accelerated from P.L. 566 funds in the amount of $62,730. The remaining cost of $252,250 will be from other funds. These costs include labor, materials, machinery, technical assistance, and costs related to the installation of the measures.

Installation cost for structural measures, as shown in Table 2, includes construction, installation services, administration of contracts, land easements and rights-of-way costs, and overhead.

Construction cost is the Engineer's Estimate of the cost of all materials and labor involved in constructing the structural measures. A 15% contingency is added to the estimated contract cost of floodwater retarding and multi-purpose structures. A 20% contingency is added to the estimated contract cost of channel improvement to defray any unexpected cost that may occur during construction. The cost estimates were based on a detailed estimate of quantities for each structure and reach of channel. The abstracts of bids of all P.L. 566 projects contracted in the state were analyzed to determine the unit prices which should be used in the cost estimate. These unit prices were found to be consistent with unit prices now being used in the Engineer's Estimates by the Soil Conservation Service, Engineering Design Unit, located at Indianapolis, Indiana.

Installation services include engineering services and other services. Engineering services include all direct P.L. 566 and other costs for the services of engineers and geologists used in designing and installing the structural measures. Examples of engineering services are construction surveys and investigations, soil and foundation drilling and testing, necessary inspection, installation assistance, preparation of plans and specifications, and similar services in carrying out construction. Other services include all overhead costs for structural measures of each agency and organization involved, as well as, direct costs for installation service provided by other than engineers and geologists.

Overhead costs include the formation of the conservancy district and its operation during the installation period and other associated costs.

Administration of contracts includes all local costs for administration, legal, and clerical services incurred by the contracting local organization in carrying out contracts.

Land, easements, and rights-of-way include the following costs:

A. All expenditures made in acquiring land, easements, and rights-of-way or their value as estimated by the local organization and the Service.

B. All expenditures for the closing, relocation, or raising of private or county roads or permission to flood these roads.

C. All expenditures for purchasing, removing, or relocating houses, buildings or other improvements, or permission to flood these facilities.

D. All expenditures for relocating or removing utility lines.

E. Relocation or reconstruction of fences.

F. Replacement or changes to bridges (no such costs are anticipated).

G. All expenditures for payment of damages to persons inconvenienced by the project due to such causes as interuption or closing of roads, interuption of utilities, and having to move.

Land rights needed for multiple purpose structure No. 1 include an area of approximately 64 acres and one barn. The barn is located in the emergency spillway cut. The permanent pool will contain about 24 acres. An additional 20 acres will be required for the flood pool. The dam site and emergency spillway will take about 10 acres. A borrow area of 10 acres was included on the northwest valley wall to be used as needed. Two additional acres will be needed for the access road, pumping station and pipe

line to the treatment plant.

Floodwater retarding structure No. 2 will require about 54 acres of land. The sediment pool and flood pool are six acres and forty-one additional acres, respectively. The remaining seven acres are for the dam site and emergency spillway area. Two houses, with out-buildings, are located in the flood pool. The county road along Souders Branch would be closed by the structure. The three houses above the flood pool will have to be purchased or have the road and utility lines rerouted to them. The utility lines above the dam will have to be relocated or taken out.

The required land rights for floodwater retarding structure No. 3 include 75 acres of land and two houses, one of which, is not used as a residence. The utility lines to the house in the valley above the flood pool will have to be relocated. The road and this house will be cut off by the structure; however, an alternate road of approximately equal quality exists. The alternate route is about three miles greater distance to the highway at Borden. An alternate borrow area of 12 acres is included in the land needed. This borrow would be located below the structure along the valley wall and would be used only if the borrow in the reservoir area became flooded or was otherwise inadequate.

Multiple purpose structure No. 4 will require about 141 acres of land. The permanent pool will contain about 30 acres. The flood pool will require an additional 58 acres. The dam and emergency spillway will take about 13 acres. Two unoccupied houses will be cut off from the road by this structure. The utility lines to these two houses will have to be removed or relocated. The dirt road to these houses will have to be abandoned or relocated. An additional 40 acres will be needed for

the recreation area connected with this structure.

The land rights needed on floodwater retarding structure No. 5 include 53 acres of land. The sediment pool and flood pool require about six acres and 28 additional acres, respectively. The dam site and emergency spillway will require about nine acres; and ten acres are included for an alternate borrow area. The alternate borrow area is along the sides of the valley below the dam and will be used only if the main borrow is inadequate.

Multiple purpose structure No. 6 will require about 45 acres for the flood pool, of which, 21 acres will be in the recreation pool. An additional nine acres will be required for the dam and emergency spillway. A recreational area of 30 acres is planned.

The land rights on multiple purpose structure No. 7 include approximately 105 acres and about 12 dwellings. The flood pool contains about 55 acres, of which, 25 acres is the permanent pool. Of the total area, 25 acres are for recreation. The emergency spillway and borrow area on the west ridge will be approximately 15 acres. The dam site will require about 10 acres. The utility lines to the houses will have to be removed.

The land rights for channel improvement include an area along the proposed channel for construction and spreading of the spoil and for maintenance. In addition, areas for ingress and egress to the channel will be needed. An estimated 357 acres will be needed during construction for room to work and spreading of the spoil. The area needed permanently for the channel and for maintenance is about 160 acres. The present use of this 160 acres is woods, pasture, and cropland. The area for the new channel, which is currently taken up by the existing one, was not included

in the easement area.

The total estimated cost for land easements and rights-of-way is $144,780, as shown in Table 2. Included in the total is $4,350 for utilities, $3,100 for roads, $31,000 for buildings, and $106,330 for land. The costs for fences and damages to persons inconvenienced is included as incidental to these items listed.

The cost of the multi-purpose structures is allocated by the use of facilities method. This method provides for the cost to be allocated to a purpose in direct proportion to the storage volume available for that purpose. A summary of the cost sharing and cost allocation is shown in Table 2A.

Multi-purpose structure No. 1 is allocated 36.6% to municipal water supply and 63.4% to flood prevention. The cost of $137,390, which is the construction and installation services allocated to flood prevention, will be borne by P.L. 566 funds. The cost of construction and installation services allocated to municipal water supply, all land easement and rights-of-way costs, all administration of contract costs, and all specific costs for raw water pumping and piping will be borne by local funds. The total cost to local organizations is estimated to be $104,710.

The cost allocation of multi-purpose structure No. 4 is 18.4% to recreation and 81.6% to flood prevention. P.L. 566 funds will provide that portion of the construction and installation services allocated to flood prevention which is estimated to be $118,910. This amount leaves a total of about $45,070 to be provided from local funds on the structures. Local funds will also provide 100% of the recreation facilities cost estimated at $57,280.

Multi-purpose structure No. 6 is allocated 26.0% to recreation and 74.0% to flood prevention. The total P.L. 566 cost is approximately $104,320, all of which, is allocated to flood prevention. The total local cost is estimated at $76,930, which includes the cost of construction and installation services allocated to recreation and all of the land easement and rights-of-way and administration of contract costs, and the total installation cost of the recreation facilities.

The total estimated P.L. 566 cost on multiple purpose structure No. 7 is $111,770. This structure is allocated 79.6% to flood prevention. The remaining 20.4% is allocated to the recreation pool. The total local cost, estimated at $73,610, includes the recreation facilities, land easements and rights-of-way, administration of contracts, and 20.4% of the construction and installation services.

An estimated schedule of Federal and non-Federal obligations for the installation of the structural measures by fiscal year is tabulated as follows:

Fiscal Year	P.L. 566	Other	Total
1st	65,460	64,990	130,450
2nd	585,200	125,540	710,740
3rd	290,180	123,020	413,200
4th	268,000	153,480	421,480
5th	557,400	12,800	570,200
Total	1,766,240	479,830	2,246,070

Non-Project Costs

All non-project costs incurred must be borne by the sponsoring local organizations. These costs are additional items not included in benefit-

cost, cost allocation, or cost sharing computations.

Non-project costs include all additional costs resulting from changes of, or additions to, project works of improvement for non-project purposes or maintenances such as (1) altering a structure to permit its use as a roadway, (2) distributing and leveling spoil or disposing of excavated material primarily to improve land, (3) filling abandoned channels or depressed areas outside of the right-of-way or to relieve local organizations of the responsibility of acquiring the necessary right-of-way, (4) constructing maintenance roads and associated culverts, (5) relocating or modifying planned works of improvement for the convenience of the sponsoring local organizations.

EFFECTS OF WORKS OF IMPROVEMENT

The works of improvement, as outlined in this plan, will have significant effect on the floodwater damages that occur, and will make possible the improvement of the agricultural land within the flood plain.

With project, flooding during the cropping season will be less frequent than once in five years in reaches V through VIII. The five year level of protection will adequately meet the requirements for the production of vegetables in this area. In reaches II through IV, the level of protection will be between a three and five year frequency. The 50 year frequency storm in present condition floods 4,718 acres. With project, this size storm will flood only about 2,110 acres, a reduction of 55%. Presently, the five year frequency storm floods 3,180 acres. After project installation, this size storm will flood about 360 acres.

The reduction of the flood hazard during the cropping season of April through November will permit the flood plain lands to be used for

the production of high value, clean tilled crops. It will permit the farmers to make a desired change to more vegetable crops in an area that is most suitable from the standpoint of soil capability and market outlet. A small acreage of vegetables is now grown, but due to the flooding hazard, has not expanded beyond a token of the market potential. It is estimated that the acreage of vegetables would be increased from 53 acres presently grown, to about 264 acres with project. A total of 2267 acres of flood plain acres will be used more intensively with project conditions. Estimates indicate that there will be no increase in the total acreage of alloted crops within the watershed as a result of this project.

The total average annual damage from floodwater and erosion, as determined by this study, amounts to $91,850. The over-all reduction of the proposed works of improvement, including the effect of the Deams Lake structure on Big Run is 90% of all damages. The reduction benefits contributed to the Deams Lake structure amount to $4,542. In addition, a more intensive use benefit of $1,887 is allocated to this structure, making a total benefit of $6,429, which is omitted from the benefit tables and the benefit-cost computation.

Floodwater damage to crop and pasture is $53,250, which represents 58% of the total floodwater damages. With project, this amount will be reduced to $8,500 - reduction of 85%. Average annual non-agriculture type of damage amounts to $22,975 - road and bridge, $5,975; Monon Railroad, $8,000; and urban (Borden), $9,000. A high level of protection to these facilities is provided by the proposed measures.

Flooding on the all season basis in the Town of Borden will be less frequent than once in ten years. However, the major portion of Borden

will be protected from flooding by Indiana State Highway 60 which serves as a levee. The 100 year frequency flood should not top this highway within the town. Damage will begin at approximately the ten year frequency over a narrow strip of land on the south side of Borden bordered by Highway 60 on the north. During the ten year storm approximately 0.5 feet of flooding will occur with a resulting storm damage of about $500; 25 year storm, approximately 1.0 feet flooding will occur with a resulting storm damage of $2500; 50 year storm, approximately 1.4 feet flooding with a resulting storm damage of $5800; and 100 year storm, approximately 2.0 feet flood with resulting damage of $8990, as compared to $70,000 storm damage for the 100 year storm in present condition. Damage in this area at the lower frequency is generally limited to small out-buildings.

It is estimated that the 50 year frequency storm, with project, will pass under the low members of the bridge at Carwood on the Monon Railroad. The low member is at elevation 500.5 feet, and the 50 year frequency stage, with project, is estimated at 498.0 feet. The estimated reduction of all non-agricultural type of damages is 90%.

Erosion damage of $2,182 will be reduced to 60% over the total flood plain.

It is estimated that about 96 farms are in the flood plain that will be directly benefited by the structural program. The acreage of flood plain benefited on an individual piece of property range in size from a residential lot of one-fourth acre to an average size farm of 120 acres. There are approximately 1,800 people within the watershed who will receive some type of benefit from this project.

The total flood plain of 4,718 acres will benefit from adequate or

improved drainage systems that now can be installed. The existing drainage systems will sustain proper drainage in areas where flooding has previously damaged these drainage systems.

Secondary benefits will accrue to trade area businesses through increased income from processing, sales, and services.

Benefits will accrue to redevelopment by utilizing local unemployed and underemployed in project installation, in performing operation and maintenance after installation, and in filling new positions created as a result of the project.

Water supply benefits will accrue to present residents of Borden and surrounding areas by eliminating the need for hauling water in from other sources for domestic use. With adequate water available, additional residents and industry will be developed.

Non-agricultural water management in the form of a water supply and water impoundment for public and organized group recreation will add substantially to the business opportunities and over-all economics of the area. It is estimated that a total of approximately 28,000 people annually will use the water oriented recreational facilities offered by Deams Lake. Approximately 17,000 visitor days are expected on the multiple purpose, P.L. 566 structures participated in by organized groups in this watershed. A total of 300 families will be served by the water supply included in structure No. 1.

The Biologist of the Soil Conservation Service and the Watershed Planning Party conducted reconnaissance studies in the watershed to determine the effect the proposed improvements would have on fish and wildlife.

The findings were that both gains and losses would result with the proposed plan in operation. Stream channel alterations would temporarily disrupt stream fishing. Total fish habitat would be greatly increased by the multi-purpose floodwater retarding structures and farm pond construction. Water quality would also be greatly improved.

A gain in wildlife is anticipated by the improvement of wildlife habitat in the watershed. This will especially be applicable to the following species of wildlife: deer, doves, squirrels, rabbits, quail, songbirds, and waterfowl.

All impounded water, including the sediment pools, will be stocked with fish. Safe trees will be left to shade stream fishing where possible in the lower reaches of the stream.

PROJECT BENEFITS

The total annual benefits of the proposed project, as shown in Table 6, are estimated at $148,585, including: (1) damage reduction due to structural measures of $74,768, (2) benefits from more intensive use

of present cropland of $18,477, (3) changed land use benefit of $4,935, (4) local secondary benefit of $14,390, (5) recreational benefit of $17,400, (6) water supply benefit of $8,060, and (7) redevelopment benefit of $10,555.

Secondary benefits from a national viewpoint, were not considered pertinent to the economic evaluation. Secondary benefits include those (1) stemming from the project, and (2) induced by the project in the way of services and materials required to make possible the increased net returns.

Benefits from recreation use of the three permanent lakes included as an integral part of this plan are mostly from fishing and camping. No incidental recreation benefits to the sediment pools of the floodwater retarding structures were considered. These pools will be shallow and would not offer good fishing or boating.

Benefit to the water supply system for Borden is on the basis of being able to furnish water to 120 property services in Borden and approximately 200 residences along Highway 60. The area along Highway 60 is rapidly building up with new residences, and the potential for water services could well double in the next twenty years.

Intangible benefits not measured in monetary terms will accrue with the installation of this project. These include benefits derived from the installation of land treatment measures by those farmers which exceed the cost of applying such measures, and a benefit to the community in a way of providing a more stable farm income to low income farmers who cannot compete with larger, more efficient type of farms. With project, these low income farms with sales of less than $2500 will be able to diversify their operations by growing small acreages of vegetables in the flood

plain for the canning factory in Austin, Indiana, and for the fresh vegetable market in Louisville, Kentucky.

COMPARISON OF BENEFITS AND COSTS

Benefit and cost comparison for the single unit of evaluation is shown in Table 6. Based on primary structural measure benefits of $134,195, and an average annual cost of $114,074, the benefit-cost ratio is 1.2 to 1. An additional benefit-cost ratio, computed by combining local secondary benefits of $14,390 with primary benefits, shows a benefit-cost ratio of 1.3 to 1.

PROJECT INSTALLATION

Land Treatment Measures

Watershed upland will be protected from excessive runoff and soil erosion by the application of land treatment measures determined by land capability classification. These measures will be incorporated into basic farm conservation plans. Technical assistance for planning and application of this work will be provided by the Soil Conservation Service.

Technical assistance for the forestry measures will be furnished by the Indiana Department of Conservation, Division of Forestry, in cooperation with the U. S. Forest Service.

The responsibility for the application of land treatment measures will rest with the Clark, Floyd, and Washington Soil and Water Conservation Districts. Necessary technical assistance will be provided, work priorities will be established, and follow up contacts will be made under the supervision of the District Supervisors.

All land treatment measures will be installed prior to or concurrently with the installation of structural works of improvement. The sponsoring

local organization will obtain agreements to carry out recommended soil conservation measures and proper farm plans from owners of not less than 50% of the lands above the proposed floodwater retarding structures.

Structural Measures

All works of improvement will be installed during a five year period. The first year may be utilized for securing easements and completing construction plans and specifications on contracts to be let the second year. In order to realize the most benefit from the structural measures, they will be installed in the following sequence:

1. Multi-purpose structure No. 1, floodwater retarding structure Nos. 2 and 3.
2. Multi-purpose structure No. 4 and floodwater retarding structure No. 5.
3. Multi-purpose structure Nos. 6 and 7.
4. Channel improvement reaches I through VI and Elk Run.

The Town of Borden will be responsible for providing that portion of the construction costs and installation services of structure No. 1 allocated to municipal water supply. The Town of Borden will be responsible for securing the land, easements and rights-of-way and to administer the contracts for structure No. 1. Borden is incorporated under the name of "The Town of New Providence" and has the power of taxation and eminent domain.

The conservancy district, now in the process of formation, will have the power of eminent domain and taxation, as provided by the Indiana Conservancy Act. The conservancy district will be responsible for securing land, easements and rights-of-way, and to administer the contracts for

the installation of all works of improvement other than structure No. 1. That portion of the construction cost and installation services to be provided from other funds will be provided through the conservancy district for all works of improvement other than structure No. 1.

The portion of the construction costs and installation services shown in Table 2 under P.L. 566 funds will be provided from these funds through the Soil Conservation Service. Engineering services, in the form of surveys, investigations, construction plans and specifications, and construction inspection for the channels and the floodwater retarding structures will be provided by the Soil Conservation Service. The Soil Conservation Service will cost share the installation services on the multiple purpose structures (1, 4, 6, and 7) with the local organizations.

As sponsors, the Soil and Water Conservation Districts in Clark, Floyd, and Washington Counties will provide such assistance and guidance as necessary to expedite coordination between the land treatment and the structural features of this plan.

The Indiana Flood Control and Water Resources Commission, in accordance with state laws and regulations, will review for approval, the plans and specifications for the works of improvement to be constructed. These laws and regulations are embodied in the Indiana Conservancy Act.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement on the lands in this watershed, as described in this work plan, will be provided under the authority of the Watershed Protection and Flood Prevention Act (P.L. 566, 83rd Congress, 68 Stat. 666). However, Federal financial assistance is contingent on the appropriation of funds to carry

out this plan.

A.C.P. cost sharing is available for the installation of land treatment measures and special available funds may be provided for this purpose. Farm owners and operators will provide the funds for their share of the installation of the land treatment measures included in this plan.

The conservancy district will provide for the financial obligations of funds estimated at $375,120, on all the structural measures except structure No. 1. The Town of Borden will provide these funds, estimated at $104,710, for structure No. 1. Specific costs of $12,400 are included for municipal water supply. Specific cost for recreational facilities of $106,670 is included in the portion the conservancy district will provide.

The conservancy district will obtain funds by the various means set forth in the Indiana Conservancy Act. The provisions of this act give the conservancy district the power of eminent domain. The conservancy district will also be responsible for securing funds from local interests for their share of the costs allocated to recreation in the three structural measures concerned.

The sponsoring local organizations have carefully analyzed the schedule of construction of the works of improvement and are prepared to have funds available as needed. A cash reserve will be made available by means of an F.H.A. loan until conservancy district funds are available. A letter of intent has been filed by the sponsors with the state director of F.H.A. to establish a line of credit. No credit assistance will be furnished under provision of P.L. 566 funds for the cost allocated to recreation on structure Nos. 4 and 6.

Table 1 shows the area of land programmed for treatment and the cost of technical assistance for forestry to be furnished by the Indiana Department of Conservation, Division of Forestry, in cooperation with the U. S. Forest Service. The technical assistance for installing forestry measures will cost $34,240, of which $15,690 will be provided under authority of P.L. 566 and $14,810 will be provided by the Indiana Department of Conservation, Division of Forestry. In addition, the Indiana Department of Conservation will provide $3,740 for technical assistance under the Cooperative Forest Management Program.

Technical assistance for land treatment measures under Soil Conservation Service is estimated at $62,220, of which $47,040 will be provided under authority of P.L. 566 and $15,180 will be provided by the regular P.L. 46 going program.

PROVISION FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land owners and operators within the watershed will maintain the land treatment measures installed on their land. This maintenance is an integral part of the cooperator work plan agreement between the cooperators and the Clark, Floyd, and Washington Soil and Water Conservation Districts. Advice and technical assistance for this maintenance work will be provided by specialists from the Soil Conservation Service for those measures in which they had installation responsibilities.

Forestry measures installed as part of this project will be maintained by landowners and operators with technical assistance provided by the Indiana Division of Forestry in cooperation with the United States Forest Service under the Cooperative Forest Management Program.

Structural Measures

The conservancy district will be responsible for the operation and maintenance of all the planned structural measures except structure No. 1. Borden will be responsible for the operation and maintenance of structure No. 1. The channels in the benefited area where no channel improvement is planned will be maintained by the conservancy district in approximately their present condition. The purpose of this provision is to prevent obstruction developing in these channels which would reduce the expected benefits. Also, any large increase in the capacity of these channels would cause additional flooding in the benefited area below.

The cost of operation and maintenance work is estimated to be $16,378 annually for the channels. The structures, excluding No. 1, are expected to cost $1,765 annually to operate and maintain. The annual cost of operating and maintaining structure No. 1 and the raw water pumping station and pipeline is estimated at $1,765. The recreation facilities are estimated to cost $2,295 annually to operate and maintain. The annual operation of the conservancy district is estimated at $2,500. These items amount to an estimated total of $24,703 annually.

Inspection of the structural measures will be made annually and as needed after severe storms. The team making these inspections will consist of, at least, a representative of the conservancy district and a representative of the Soil Conservation Service. Additional organizations which should be informed of scheduled inspections, include the Indiana Flood Control and Water Resources Commission and any local organizations such as the Town of Borden, involved with the particular measure. A record of the inspection will be kept in the file of the conservancy

district and will be available for authorized inspections.

Land owners, on whose land the structural works are located, may enter into agreements with the conservancy district for maintenance. These agreements will specify the maintenance land owners are to perform, such as (1) reseeding and fertilizing of embankments and channel banks, (2) isolated channel spraying or mowing, and (3) removal of minor debris blocks in the channels and at the entrance to spillways. It is estimated that this work will amount to about 25% of the total operation and maintenance cost.

Other operation and maintenance work requiring special equipment, or otherwise beyond the capacity of the landowner, will be carried out by the proposed conservancy district by force account or contract. This includes such items as: (1) repairing of major damage to structure embankments and to spillways, (2) major streambank spraying, and (3) major repair or cleanout of stream channel bottom and banks. The conservancy district, now in the process of formation, will acquire, by the various means set forth in the Indiana Conservancy Act, the funds for operation and maintenance.

Specific operation and maintenance agreements will be executed between the conservancy district and the Soil Conservation Service prior to the issuance of invitations to bid on construction. In the case of structure No. 1, this agreement will be between the town and the Soil Conservation Service.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Muddy Fork of Silver Creek Watershed

Installation Cost Item	No. to be Applied		Estimated Cost (Dollars) 1/		
	Unit	Non-Federal Land	P.L. 566 Non-Federal Land	Other Non-Federal Land	Total
LAND TREATMENT FOR WATERSHED PROTECTION					
Soil Conservation Service					
Cropland	Acre	7,892		110,410	110,410
Grassland	Acre	2,768		32,550	32,550
Idle and Miscellaneous	Acre	2,198		3,080	3,080
Adm. & Supervision				21,900	21,900
Technical Assistance			47,040	15,180	62,220
SCS Subtotal			47,040	183,120	230,160
Forest Service					
Woodland	Acre	18,650		50,580	50,580
Technical Assistance			15,690	18,550	34,240
FS Subtotal			15,690	69,130	84,820
TOTAL LAND TREATMENT			62,730	252,250	314,980

1/ Price Base 1963

October 1964

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Muddy Fork of Silver Creek Watershed

Installation Cost Item	No. to be Applied: Unit	No. to be Applied: Non-Federal Land	Estimated Cost (Dollars) 1/: P.L. 566 Non-Federal Land	Estimated Cost (Dollars) 1/: Other Non-Federal Land	Total
STRUCTURAL MEASURES					
Construction Cost					
Soil Conservation Service					
F.W.R. Structures	No.	3	510,300		510,300
Multi-Purpose Structures	No.	4	351,280	128,310	479,590
Pumping Sta. & Pipe Lines				10,000	10,000
Basic Rec. Fac.				76,500	76,500
F.P. Channel Improvement	Miles	12.5	477,400		477,400
Subtotal Construction			1,338,980	214,810	1,553,790
Installation Services					
Soil Conservation Service					
Engineering Service			327,260	46,140	373,400
Other Service			100,000	13,420	113,420
Subtotal Inst. Services			427,260	59,560	486,820
Other Costs					
Overhead				30,000	30,000
Land Easements & R/W				144,780	144,780
Adm. of Contracts				30,680	38,680
Subtotal Other Costs				205,460	205,460
TOTAL STRUCTURAL MEASURES			1,766,240	479,830	2,246,070
TOTAL PROJECT			1,828,970	732,080	2,561,050
SUMMARY					
Subtotal SCS			1,813,280	662,950	2,476,230
Subtotal FS			15,690	69,130	84,820
TOTAL PROJECT			1,828,970	732,080	2,561,050

1/ Price Base 1963

October 1964

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(At Time of Work Plan Preparation)

Muddy Fork of Silver Creek Watershed

Measures	Unit	Applied To Date	Total Cost (Dollars)
LAND TREATMENT			
Cons. Crop. System	Acres	1,636	$ 1,640
Contour Farming	Acres	1,290	260
Cover Crop	Acres	2,419	14,500
Crop Residue Utilization	Acres	2,271	2,270
Diversions	Feet	11,610	1,620
Ponds	No.	37	22,200
Structures (Stabilization)	No.	11	2,200
Grass Waterways	Acres	14.1	1,860
Pasture Planting	Acres	895	35,800
Terraces	Feet	72,920	4,370
Tile	Feet	124,720	27,440
Tree Planting	Acres	27.3	950
Livestock Exclusion	Acres	2,328	9,310
Mains and Laterals	Feet	8,150	3,670
Strip Cropping	Acres	59	60
Stream Channel Improvement	Feet	6,200	6,200
Subtotal Land Treatment			$ 134,350
STRUCTURAL MEASURES			
Deams Lake			$ 662,000
Recreation Facilities			50,000
Subtotal Structural Measures			$ 712,000
TOTAL			$ 846,350

October 1964

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION
Muddy Fork of Silver Creek Watershed
(Dollars) 1/

Measure	Install. Cost - P.L. 566 Funds				Installation Cost - Other Funds						Total Inst. Cost
		Inst. Services		Total		Inst.		Adm. of	L.E.	Total	
	Constr.	Engrg.	Other	P.L. 566	Constr.	Serv.	Overhd	Contr.	& R/W	Other	
Structures											
Str. No. 1	104,930	24,600	7,860	137,390	60,570	18,740	4,000	3,100	5,900	92,310	229,700
Pump Sta. & Pipe Lines					10,000	2,000		200	200	12,400	12,400
Str. No. 2	178,000	36,500	11,200	225,700			4,000	3,300	20,000	27,300	253,000
Str. No. 3	197,300	38,480	12,310	248,090			2,500	3,700	12,550	18,750	266,840
Str. No. 4	87,440	24,480	6,990	118,910	19,720	7,100	3,500	2,000	12,750	45,070	163,980
Rec. Fac.					42,500	7,980		800	6,000	57,280	57,280
Str. No. 5	135,000	36,450	10,800	182,250			1,800	2,600	4,140	8,540	190,790
Str. No. 6	76,720	21,460	6,140	104,320	26,960	9,700	2,000	3,100	4,050	45,810	150,130
Rec. Fac.					22,000	4,180		440	4,500	31,120	31,120
Str. No. 7	82,190	23,000	6,580	111,700	21,060	7,580	4,000	2,000	20,700	55,340	167,110
Rec. Fac.					12,000	2,280		240	3,750	18,270	18,270
Subtotal Structs.	861,580	204,970	61,880	1,128,430	214,810	59,560	21,800	21,480	94,540	412,190	1,540,620
Channel Improvement											
Reach I	5,760	1,730	460	7,950			100	100	1,020	1,220	9,170
Reach II	67,320	16,830	5,400	89,550			1,000	1,300	12,600	14,900	104,450
Reach III	139,680	34,900	11,100	185,680			2,500	2,700	10,440	15,640	201,320
Reach IV	134,880	33,720	10,770	179,370			2,500	2,600	10,440	15,540	194,910
Reach V	74,760	19,440	5,990	100,190			1,000	1,400	8,670	11,070	111,260
Reach VI	38,800	10,860	3,100	52,760			800	800	5,280	6,880	59,640
Reach IX (Elk Run)	16,200	4,810	1,300	22,310			300	300	1,790	2,390	24,700
Subtotal Ch. Impmt.	477,400	122,290	38,120	637,810			8,200	9,200	50,240	67,640	705,450
GRAND TOTAL	1,338,980	327,260	100,000	1,766,240	214,810	59,560	30,000	30,680	144,780	479,830	2,246,070

1/ Price Base 1963

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TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY
Muddy Fork of Silver Creek Watershed

(Dollars) 1/

Item	Purpose			
	Flood Prevention	Recreation	Municipal Water	Total
Single Purpose				
F.W.R. Structures & Channel Imp.	1,416,080			1,416,080
Multi-Purpose				
Str. No. 1	145,630		84,070	229,700
Pump Sta. & Pipe Lines			12,400	12,400
Str. No. 4	129,540	34,440		163,980
Rec. Facilities		57,280		57,280
Str. No. 6	111,100	39,030		150,130
Rec. Facilities		31,120		31,120
Str. No. 7	133,020	34,090		167,110
Rec. Facilities		18,270		18,270
TOTAL	1,935,370	214,230	96,470	2,246,070
P.L. 566	1,766,240	-	-	1,766,240
Other	169,130	214,230	96,470	479,830
TOTAL	1,935,370	214,230	96,470	2,246,070

1/ Price Base 1963 October 1964

TABLE 3 - STRUCTURE DATA

Floodwater Retarding and Multiple Purpose Structures

Muddy Fork of Silver Creek Watershed

Item	Unit	Structure Number 1	2	3	4	5	6	7	Total
Drainage Area	Sq.Mi.	2.01	3.19	3.84	4.33	2.40	2.60	1.84	20.21
Storage Capacity									
Sediment	Ac-Ft.	23	29	69	35	27	28	20	231
Floodwater	Ac-Ft.	410	615	620	709	442	445	476	3,717
Rec. Water Supply	Ac-Ft.	0	0	0	168	0	166	127	461
Mun. Water Supply	Ac-Ft.	250	0	0	0	0	0	0	250
Total	Ac-Ft.	683	644	689	912	469	639	623	4,659
Between High&Low Stg.	Ac-Ft.	171.5	272	266	232	205	222	149	1,517.5
Surface Area									
Sediment Pool	Acre		6	11		6			23
Floodwater Pool	Acre	40	47	47	79	34	45	55	347
Recreation Pool	Acre	0	0	0	30	0	21	25	76
Water Supply Pool	Acre	24	0	0	0	0	0	0	24
Volume of Fill	Cu.Yd.	215,000	184,000	198,000	142,500	199,000	152,000	111,000	1,201,500
Elevation Top of Dam	Feet	648.5	654.5	677.0	580.5	606.5	583.5	547.0	
Maximum Height of Dam	Feet	47	52	56	37.5	53	46.2	32	
Emergency Spillway									
Crest Elevation	Feet	639.0[2]/	637.0	650.5	576.5	592.0[2]/	574.5	541.0[2]/	
Bottom Width	Feet	150	50	25	400	80	300	25	
Type		Shale[3]/	Shale[3]/	Shale[3]/	Sod	Shale[3]/	Sod	Shale[3]/	
Percent Chance of Use		1	1	1	2	1	1	2	
Ave. Curve No.-Cond. II		83	83	79	81	83	83	82	
Emerg. Spillway Hydrograph									
Storm Rainfall(6 hr)	Inches	10.15	10.15	10.15	7.1	10.15	10.15	7.1	
Storm Runoff	Inches	8.05	8.05	7.54	4.90	8.05	8.05	5.01	
Velocity of Flow(Vc)	1/ft/sec	8.25	11.7	14	6.8	11	8.4	2.0	
Discharge rate 1/	c.f.s.	2650	2500	2140	3900	3300	5650	6	
Max. W/S Elev. 1/	Feet	642.7	643.75	659.6	579	598.1	578.3	541.3	

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TABLE 3 - STRUCTURE DATA

Floodwater Retarding and Multiple Purpose Structures

Muddy Fork of Silver Creek Watershed

Item	Unit	Structure Number 1	2	3	4	5	6	7	Total
Freeboard Hydrograph									
Storm Rainfall (6 hr)	Inches	26.5	26.5	26.5	13.45	26.5	26.5	13.45	
Storm Runoff	Inches	24.19	24.19	23.56	10.98	24.19	24.19	11.13	
Veloc. of Flow(V_c) 1/	ft/sec.	13.8	19.9	23	8.3	18	13.2	11.1	
Discharge Rate 1/	c.f.s.	11,850	11,700	11,750	7,500	14,025	21,500	1,065	
Max. W/S Elev. 1/	Feet	648.1	654.2	677.6	580.4	606.4	583.2	546.9	
Principal Spillway									
Capacity-Low Stage	c.f.s.	20	30	38	43	24	26	18	
Capacity-High Stage	c.f.s.	110	108	145	118	113	120	105	
Storm Rainfall	Inches	4.47	6.35	6.35	6.30	4.47	4.47	4.12	
Storm Duration	Hour	6	30	30	42	6	6	6	
Runoff Curve No.		90	83	79	81	90	90	89	
Storm Runoff	Inches	3.37	4.42	4.00	4.16	3.37	3.37	2.94	
Capacity Equivalents									
Sediment Volume	Inches	0.21	0.17	0.33	0.15	0.21	0.18	0.15	
Detention Volume	Inches	3.82	3.61	3.03	3.07	3.45	3.21	4.85	
Spillway Storage	Inches	4.38	6.44	8.69	1.46	4.96	3.00	4.03	
Class of Structure		c	c	c	b	c	c	b	

1/ Maximum during passage of hydrograph

2/ Raised above requirement due to shale excavation in the emergency

3/ Borden Shale

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CHANNELS

Muddy Fork of Silver Creek Watershed

Channel Designation	Sta. No. for Reach Sta. (100 Ft.)	to Sta. (100 Ft.)	Watershed Area 1/ Sq.Mi.	Purpose 2/	Required Channel Capacity c.f.s.	"n"	Grade Ft/Ft	Bottom Width Feet	Side Slope	Ave. Depth Feet	Average Channel Area Sq.Ft.	Average Velocity Ft/Sec.	Volume of Excavation 1000 CuYd.
Reach I	1065	1036	42.94	F.P.	3370	.04					952	3.54	0 3/
	1036	1032	42.94	F.P.	3370	.04	.0008	40	2:1	13.9	942	3.58	2.7
Reach II	1032	940	35.31	F.P.	3000	.04	.0008	40	2:1	12.9	849	3.53	200
Reach III	940	842	31.79	F.P.	2800	.04	.0009	40	2:1	11.2	699	4.00	403
	842	775	28.50	F.P.	2650	.04	.0009	40	2:1	10.5	641	4.13	
Reach IV	775	737	23.50	F.P.	2400	.04	.0009	40	2:1	10.5	640	3.75	
	737	731	23.50	F.P.	2400	.05	.0009	40	2:1	10.2	616	3.90	
	731	713	23.50	F.P.	2400	.04	.0009	40	2:1	10.6	649	3.70	300
	713	672	21.00	F.P.	2750	.04	.001	40	2:1	11.3	707	3.89	
	672	649	21.00	F.P.	2750	.04	.0014	30	2:1	11.1	580	4.74	
Reach V	649	613	18.80	F.P.	2600	.04	.0017	24	2:1	10.7	486	5.34	190
	613	535	15.70	F.P.	2250	.04	.0018	24	2:1	10.3	459	4.90	
Reach VI	535	506	14.65	F.P.	2150	.04	.0018	24	2:1	9.6	415	5.18	83
	506	467	13.40	F.P.	2050	.04	.0018	24	2:1	9.4	402	4.10	
Elk Run	200	133	6.62	F.P.	854	.04	.004	14	2:1	6.27	616	5.14	19
	133	49	4.70	F.P.	732	.04					149	4.91	0 3/

1/ Watershed area excludes the controlled area

2/ Flood Prevention - F.P.

3/ Clearing, snagging and seeding only

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TABLE 4 - ANNUAL COST
Muddy Fork of Silver Creek Watershed

(Dollars)1/

Evaluation Unit	Amortization of Installation Cost 2/	O & M Cost 3/	Total
Structures 1 through 7 and Channel Improvement Reaches I through VI and Elk Run	89,371	24,703	114,074
TOTAL	89,371	24,703	114,074

1/ Price Base 1963 for Installation Cost - Projected Long Term Cost for O & M.

2/ Amortized at 3-1/8% for 50 years.

3/ Includes O & M to maintain present capacity in reaches where no construction is planned.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
Muddy Fork of Silver Creek Watershed, Indiana

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Crop and Pasture	53,250	8,500	44,750
Other Agricultural	5,093	895	4,198
Non-Agricultural			
Road and Bridge	5,975	920	5,055
Railroad	8,000	1,200	6,800
Urban	9,000	350	8,650
Subtotal	81,318	11,865	69,453
Erosion (Flood Plain Scour)	2,182	869	1,313
Indirect	8,350	1,175	7,175
TOTAL	91,850	13,909	77,941

1/ Projected long term prices

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES
Muddy Fork of Silver Creek Watershed

(Dollars)

Measure	AVERAGE ANNUAL BENEFITS									
	Flood Prevention									
	Damage Reduction	Changed Land Use Agric.	More Intens. Use Cropland	Local Secondary	Recreation	Water Supply	Redevelopment	Total Benefit	Average Annual Cost	Benefit Cost Ratio
Structures 1 through 7 & Chan. Improvement Reach 1 through 6 and Elk Run	74,768 2/	4,935	18,477	14,390	17,400	8,060	10,555	148,585	114,074	1.3-1

1/ Price Base 1963 for installation cost. Projected long term prices for benefits and O & M.

2/ In addition, land treatment will provide flood reduction benefits of $3,173.

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INVESTIGATIONS AND ANALYSES

Project Formulation

This plan was conceived and formulated for the purpose of reducing flood damages within the flood plain, improving farm income, and as an integral part of the over-all economic development of the area.

The Clark, Floyd, and Washington County Soil and Water Conservation Districts have been operating for over ten years for the purpose of reducing water runoff, soil loss and improving agricultural water management. Land treatment measures alone, it was soon recognized, did not bring about the desired reduction of flood plain damages. Most of these measures offered on site benefits and control to local problems. However, for some time, local interests have pursued the possibilities of flood protection under P.L. 566. Application for assistance under P.L. 566 was made in October 1960. Since this time local interest has been working for a comprehensive watershed work plan including features that provide for flood protection, recreation, and municipal water supply. Different combinations of possible measures were considered in selecting a feasible, integrated project capable of rendering these desired features.

Land Use and Land Treatment

A determination of the land treatment needs and land use conversion required was one of the first steps in formulation of the over-all project. Land capability units and the proportions of the land use categories in the watershed provided acreage figures for these groupings. Some of these data was obtained from the Clark, Washington, and Floyd County Conservation Needs Inventory and adjusted to the problem areas within the watershed. Combination of land treatment measures and the necessary land use conversion

applicable to each land capability unit were determined and summarized.

The costs for technical assistance and for the installation of these measures was then determined. A summary of these costs is shown in Table 1.

Hydrologic and Hydraulic Investigations

Hydrologic and hydraulic investigations conducted for the watershed were used in developing physical data for the economic evaluation and the design of proposed works of improvement.

There being no active U. S. Geological Survey stream gaging stations available in the watershed, rainfall data were used for project evaluation. The U. S. Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," was chosen as the source of rainfall frequency. The data from the rain gage, located at Jeffersonville, Indiana, approximately fourteen miles southeast of this watershed, has been integrated into the T. P.-40 frequency studies by the U. S. Weather Bureau.

The Soil Cover Complex Curve Numbers reflecting present conditions for individual structures and the entire watershed were developed by field investigations and the use of data furnished by the Work Unit Conservationist and Soil Scientist. Soil Cover Complex numbers for future conditions were developed by assuming the land treatment measures installed during the installation period of the project. The average runoff curve number for present watershed conditions was calculated as 80 and for future condition as 78.

The design runoff curve number for each structure was developed by evaluation of the watershed conditions above each site. These curve numbers are deemed accurate enough for final design. Runoff for

the design frequency of the principal spillway was obtained from either the 6-hour duration rainfall values in T. P.-40 using antecedent moisture condition II½ or by the method set forth in SCS, T.R.-10 using antecedent moisture condition II.

The emergency spillway and freeboard design were based upon Soil Conservation Service criteria. The criteria, as established by Engineering Memorandum--Indiana 7, dated January 9, 1963, were adhered to for all hydrologic criteria. The spillway design data, along with other structural information, are shown in Table 3.

The main channel of Muddy Fork of Silver Creek, from Speed, Indiana, to the headwater areas, was divided into eight evaluation reaches based on hydraulic, economic, and physical characteristics. Nineteen full valley and fifteen road and bridge cross sections were surveyed to mean sea level datum. Stage-discharge curves were prepared for each full valley cross-section, approach section, bridge section, and exit section using the procedure set forth in Technical Release No. 14, "Computation of Water Surface Profiles and Related Parameters by the IBM 650 Computer." The storage-indication flood routing procedure was used in routing the 50, 10, and 3 year frequency floods during the cropping season through the main stream under present and future conditions with the proposed works of improvement of the project assumed to be in place. Also the storage-indication flood routing procedure was used to route the 50, 10, and 3 year frequency flood for all season storms through the Town of Borden to evaluate urban damage. A routing of land treatment and structures 1, 2, 3, 4, 5, 6, 7, and Deams Lake failed to provide the desired level of protection. It was finally determined by routings that a

combination of land treatment, structures 1, 2, 3, 4, 5, 6, 7, and Deams Lake, and five year channel improvement in reaches VI and V, and 3 year channel improvement in reaches IV, III, II, and I would give desired level of protection to the agricultural flood plain. A three year channel was routed in the Elk Run tributary and found to be essential. A six hour duration storm was used for damage appraisal.

Triangular hydrographs were developed based on time of concentration using the method set forth in E & WP Hydrology Memo #4 for obtaining the peaks. These hydrographs were routed and accumulated down the main channel through the routing reaches.

The peak discharges were determined at the foot of each routing reach by the storage-indication method of routing. The peak rates of discharge at intermediate cross-sections within the routing reaches were interpolated by a logarithmic relationship between drainage area and the rate of discharge, using the concordant flow principle.

Stage-area inundated curves were developed for each selected reach. Stage-area inundated tables, 0-2 feet depth and over 2 feet depth, were prepared for each evaluation reach. This information was then coordinated with stage-discharge and discharge-frequency curves.

Recurrent flooding during the growing season and the effect of backwater from Silver Creek have been considered and included in the hydrologic and hydraulic conditions. The period between April and November was determined to be the growing season for project evaluation. Ninety percent of the yearly rainfall was used to compute the growing season rainfall in project evaluation.

For some storms the peak outflow from Muddy Fork will be slightly higher. However, any resulting increase in stage on Silver Creek would not be measurable.

Engineering Studies, Design, and Cost Estimates

The waterflow control studies include the proposed project and several variations. An alternate project, which would provide a five year level of protection, was studied. Approximately 16 additional structure sites were considered. Most of these sites were either too small to add significantly to the benefits, or the cost was too high in comparison to the benefits or reduction of the channel costs. Alternate sites for most of the planned sites were considered. The final sites were picked based on the following considerations, (1) the cost of each alternate, (2) the difference in the benefited area and total benefits, and (3) the desires of the local people. The channel improvement was considered supplementary to the structures. The works of improvement, as set forth in this plan, were determined to be the most practical to achieve the objectives of the local organization.

The basic data used in structure evaluation and design was obtained from U. S. Geological Survey topographic maps, aerial photographs, field surveys, hand auger borings, and field observations. All preliminary designs and evaluations were made from a study of the U.S.G.S. topographic maps, stereoscopic studies, and field observations by the Planning Engineer and Geologist.

Complete topographic surveys of sufficient accuracy to be used in final design were made of the reservoir areas on structure No. 4 and Deams Lake. A topographic map was made on these two sites with a two

foot contour interval. Stage versus storage and surface area curves were prepared from these maps and compared with those made from the U.S.G.S. topographic map with a ten foot contour interval. The difference between the two curves for structure No. 4 was between 4% and 5%. The difference on Deams Lake was less than 1%. These topographic surveys and maps were made on Deams Lake prior to the time it was learned that this site was to be designed and built from state funds.

The storage and area flooded versus stage curves for all other sites were developed from the U.S.G.S. topographic maps. Field surveys were made along the centerline of the fill of each site included in this work plan. Additional sections were surveyed in the reservoir areas of some of the sites to use in checking the accuracy of the U.S.G.S. maps. A partial topographic survey was made of the emergency spillway areas on all sites except numbers 5 and 6. A single cross-section of the emergency spillway area was made on structure numbers 5 and 6. Cross-sections and topographic maps of the emergency spillway areas were used along with other data in determining the size, elevation, and amount of excavation expected from the emergency spillways. The centerline sections were used to determine the amount of fill yardage for the embankment. It was possible to determine improvements to be involved or not involved from the U.S.G.S. topographic map and field observations. All of the field surveys were based on sea level datum.

Planning Engineer and Geologist made joint field investigations of all structure sites. Hand auger borings were made in all emergency sites to determine the depth to rock except structure No. 3 where the rock was exposed. The Geologist made hand auger borings and probings

in the foundations of all multi-purpose sites to determine more accurately the depth of the foundation and the probable strength and permeability problems.

The structures are designed to meet the criteria contained in Engineering Memorandum--Indiana 7, Engineering Memorandum--SCS-27, and other applicable SCS Engineering Memorandums, and the minimum design standards of the Indiana Flood Control and Water Resources Commission.

The requirements for sediment storage, as determined by the Geologist, were used to set the elevation of the low stage inlet of the floodwater retarding structures. The calculated 50-year sediment yield was used for all structures.

The elevation of the low stage for structure No. 1 was based on allowing enough storage for the estimated 50-year sediment yield and the requested municipal water supply volume. The low stages for multi-purpose structure numbers 4, 6, and 7 were set at an elevation which would give a conservation pool of the size requested by the sponsoring local organization.

The release rate and storage for the low stage of each structure was determined by the downstream channel capacity and the desired level of protection. In each case, the release rate of the low stage is 10 c.s.m. (cubic feet per second per square mile of drainage area). The low stage storage, which sets the elevation of the high stage, is equal to the five year cropping season runoff using AMC II$\frac{1}{2}$ for all structures.

The principal spillway conduit size was that which gave the most economical design. All the pipe conduit sizes are 30 inch diameter except

for structure No. 3 which is 36 inch diameter.

The minimum crest elevation of the emergency spillway was determined by flood routing a 100 year frequency storm on all structures except numbers 4 and 7. On structure No. 4 a 50-year frequency storm was used. The inflow hydrographs were based on either a 6-hour duration storm using Antecednet Moisture Condition II$\frac{1}{2}$ or the procedure given by Technical Release No. 10, using a longer duration rainfall and Antecedent Moisture Condition II. The runoff curve numbers used were determinded by the Hydrologist. The inflow hydrographs were developed by the C.T.U. method given in Section 3.21 of the Hydrology Guide. The flood routing was done by a mathematical method based on the principal that the incremental inflow minus the incremental outflow is equal to the change in storage. (I- O = $\triangle$ S page 3.17-1, Hydrology Guide.) The time interval used was equal to the time interval used in the inflow hydrograph. This method has been compared with the graphical method on several existing flood routings and found to be at least as accurate as the graphical method. In the case of structure No. 1 and structure No. 7, a more economical design was obtained by raising the crest elevation of the emergency spillway above that required, thereby, reducing the amount of rock excavation from the emergency cut. The flood storage available in structure No. 7 is higher than the runoff from the 50-year storm, therefore, the principal spillway hydrograph for this structure was not flood routed.

The dimensions of the emergency spillway and the elevation of the top of the dam were based on the flood routing of the freeboard hydrograph and the economics of the site. Considered in the economics of the site

were the elevation of bedrock and estimated cost of rock excavation, and the amount of fill in the dam. Also the location of roads and buildings and the value of the land was considered. The capacity of the emergency spillway was determined by the procedures set forth in Technical Release No. 2 and Supplement A to T.R. No. 2. The inflow hydrograph and flood routings were accomplished in the same manner as described for the principal spillway.

The peak inflow and total runoff only were determined for the emergency inflow hydrograph. This hydrograph was flood routed by an approximate method.

A 24 inch slide headgate and 24 inch pipe conduit were planned at the bottom of the drop inlet. The elevation of the conduit invert is planned so that the reservoir area can be drained. This feature will help to keep the borrow located in the reservoir area dry. Alternate borrow in some cases is below the dam or on top of the hill which would require longer hauls and more seeding. The installation of a gated outlet increases the efficiency of construction and should, therefore, reduce the cost per cubic yard of fill.

The embankment and foundation design is based on the geological report, an analysis of data from similar materials in other sites, and the data furnished by A.M. Kinney, Inc., consulting engineers, on the Deams Lake site. Slope stability analysis was run for general conditions, as shown by the geological reports for each site. A positive cut off to shale is expected in each site, although the soil mechanics laboratory report may indicate that this is neither necessary, nor desirable for some of the deeper sites. The primary problem on sites with foundation

depths of 15 feet to 20 feet is expected to be the strength of the material. On sites 1, 4, and 6 the downstream slopes used to compute yardage is $2\frac{1}{2}$:1, and the upstream slope is 3:1. The sites with foundation depths of 15 feet or more, as indicated by the geological report, are planned with compound slopes. The downstream slopes on these sites (numbers 2, 3, 5, and 7) are $2\frac{1}{2}$:1 with a compound slope of 10:1 at the bottom. The upstream slope on these structures is 3:1 and 5:1. A foundation trench drain was planned for each site. A core trench to bedrock with a 12 foot bottom and 1:1 side slopes is planned on each site. Yardage computations include ten percent added for irregularities in the terrain and foundation consolidation.

Riprap is included in the cost estimates on all multi-purpose sites from the high stage inlet to a few feet below the low stage for structure numbers 4, 6, and 7, and to the bottom of the slope for structure No. 1.

Clearing estimates are based on aerial photographs and U.S.G.S. topographic maps. The clearing costs are based on the wooded area below the high stage elevation of each site. All areas above the normal waterline where the sod has been removed and all fill not covered by riprap will be seeded.

The easement area needed includes the surface area at the elevation of the emergency spillway for all class "c" structures and the surface area at the maximum water surface of the emergency hydrograph for the two class "b" structures. The value of the land per acre and improvements was set by the local organization after consulting with local appraisers. The amount of easement costs were determined by (1) the value of all

improvements or the estimated cost of moving them, (2) the value of the land needed for the dam site, emergency spillway, borrow, and permanent pool, and (3) one-half the value of the land in the flood pool.

The annual operation and maintenance costs for the structures is taken from drawing SCS-3-L-46170, sheet number 1.

The municipal water storage in structure No. 1 is 250 acre-feet which is the equivalent of 2.33 inches of runoff from the watershed of the structure. Based on low flow data from streams in the vicinity, a 20-year frequency drought of one year duration should yield between two and three inches depending on the watershed size and characteristics. According to the agreement of the Borden Town Board and W. George Keat and Associates, the 250 acre-feet planned is adequate to meet the expected future needs.

The permanent storage in structures 4, 6, and 7 will require less runoff to fill than structure No. 1, and there will be no constant demand on the supply other than through evaporation and seepage losses. Therefore, these sites should have a very adequate yield from the drainage area above them.

The channel design and estimates were based on field surveys, U.S.G.S. topographic maps, aerial photographs, field observations, and photographs. The full valley and channel cross sections used by the Hydrologist were used to determine the bank full elevations and the grades of the designed channel. Surveyed and measured data were obtained on some of the bridges. The data from other bridges was obtained from photographs taken perpendicular to the span with a surveying rod next to the bridge for scale. Hand auger borings were made at points where

there was a question about the depth to bedrock.

Reach I of the channel is designed to provide an outlet for the reaches above. This reach is planned with clearing, snagging, and seeding from the outlet to the highway, U. S. 31 bridge. Backwater data for this section were taken from the IBM 650 data run by the Hydrologist. These data included a present condition water surface profile and a profile with roughness factor (n) of the channel reduced 0.015 to get the water surface profile for the proposed work.

Reaches II, III, and the lower part of Reach IV are designed to contain the three year cropping season flow within banks. Water surface profiles were run on all reaches of the main channel. The water surface of the three year flow will be above bank full along the upper part of Reach I and the lower part of Reach II; however, surveyed cross-sections indicate that the area flooded will be small. Reaches III and IV will have small areas of low ground and sloughs, for which it is not economical to provide the designed level of protection.

The water surface profile computation for the upper part of Reach IV and reaches V and VI were started with normal depth for the five year flow below the bridge near the upper end of Reach III. The channel in these reaches is designed to provide a five year cropping season level of protection. The flood plain along these reaches will also have small areas which will not receive the benefits of a five year level of protection. In some cases the water surface of the design flow is below bank full. These areas will, therefore, receive slightly more than the planned level of protection.

Head losses for all restricting bridges were computed and included in the water surface profile computations.

The roughness factor used in the channel design was somewhat higher than usual for this size and type of channel. The old channel will frequently cross and run near the new channel, which will cause an increase in the "n" value. A short portion of the channel at Wilson is designed with an "n" value of 0.05. This is due to the relatively sharp curve and the fact that riprap will be used on the outside bank of the curve.

The alignment of the channel generally follows the existing channel. The curves in the new channel will generally have a 600 foot or longer radius; two will have a 500 foot radius. The curve at the Wilson bridge will have a 200 foot radius. This curve will have riprap on the outside slope of the channel. The curve just upstream from the bridge near the lower end of Reach III will have a 200 foot radius. The bottom of the channel and most of the sideslope on the outside of the curve will be shale. The shale is exposed at this point in the present channel.

Many alterante routes were considered for the channel location. These routes were studied in the field and office to determine the most practical location. The proposed route was reviewed with the local sponsors. They agreed to the location which is set out in this plan.

The side slopes of the channel will be 2:1. This decision was based on discussion with the Geologist of the materials involved, observation of the existing channel banks, and consideration of the velocities involved.

The design depth of the channel is greater than normal depth throughout most of the channel. The maximum velocity of 4.22 feet per second in the three year channel occurred in Reach III at station 843+00.

The maximum velocity in the portion of the channel designed for a five year level of protection is 5.42 feet per second and occurs at station 613+00 in Reach V.

The quantities of clearing were determined from aerial photographs. The location of approximately 90 appurtenances were determined from the topographic maps and aerial photographs and included in the cost estimates. The side slopes of the channel, the berm and the inside slope of the spoil bank will be seeded. At locations where the spoil is stacked with a steep slope on both sides, the entire spoil bank will be seeded. Land values were furnished by the local people as described for structures.

The Elk Run channel is designed for flow at normal depth. It is planned to provide a three year level of protection. A minor amount of straightening and enlargement is needed in the lower part of this channel. The portion where clearing, snagging, and seeding is planned, is sufficient in size at the present time but needs the obstructions removed and the "n" value reduced. No appurtenances are planned on the Elk Run channel since only a minor amount of excavation is involved and existing inlets will not be appreciably disturbed.

The operation and maintenance costs were taken from curve number 2 on drawing SCS-3-L-46170, sheet 2.

Geological, Sedimentation, and Erosion Investigations

Preliminary geologic site investigations were conducted at the seven proposed dam sites. Channel banks and bottoms, flood plains and valley walls were carefully studied. Hand auger borings were made and over-burden, as well as, bedrock exposures were examined. The information thus obtained was considered with relation to foundation stability

and general site qualification. All sites appear to be feasible from a geological standpoint. Preliminary site investigation reports on form SCS-375 were prepared for each site. These reports contain pertinent information regarding abutments, foundations, spillways, and borrow materials.

The emergency spillways of several of the structure sites will be excavated into Borden Shale. Borden Shale is a dense, nearly impervious formation which is generally resistant to erosion. A study of side spillways excavated in this formation shows that weathering and erosion damage can be easily repaired by normal maintenance. Since the emergency spillways of the structures outlined in this plan will be infrequently used, no serious problem is expected.

The firm of W. George Keats and Associates was engaged by one of the sponsoring local organizations to determine feasibility of sites 1, 2, and 4 for permanent water storage. This firm has determined the sites to be so feasible. Site No. 1 will be utilized for multi-purpose water storage.

Each site is to be investigated in detail preparatory to design. The estimated cost for these investigations is noted on form SCS-375 and included in the Installation Services cost for each structure as shown on Table 2.

Design data for sediment storage were provided to the Planning Engineer for each structure. The procedure employed is described under Erosion Investigations, and is adequate for final design. A review was made of deposition in the upper margins of existing structures in the Elk Creek Watershed which is nearby. This provided additional information

on which to base sediment design. Forms SCS-309 were prepared for each site.

Soil investigations were made at locations where channel works of improvement involved channel relocation and/or channel deepening. These investigations were made with a hand auger. No problems are anticipated relative to channel bank stability, nor is any rock excavation anticipated in this phase of the structural works of improvement.

Field studies were carried out to determine the extent of land damage due to sediment. These studies were made along surveyed and plotted full valley cross-sections prepared for the use of the Party Hydrologist and the Party Economist. Several additional cross-sections or ranges were selected in order to provide a minimum of three cross-sections per damage reach. Soil borings were made and the surface conditions were carefully studied at each cross-section or range. The effect of overbank waterflow was discussed with farmers as it related to any type of land damage.

Although all types of land damage found were recorded, sediment damage was considered insufficient to warrant evaluation. As mentioned elsewhere in this plan, channel filling is not progressive and is considered inseparable from floodwater damages.

Erosion studies were made in the drainage area above proposed structural measures. Sheet erosion data in the form of land use, crop rotations and management practices were provided by the Work Unit Conservationist. These data, employed with the Universal Soil Loss Equation, indicated the expected soil loss on cropland. Other types of erosion were estimated based on the observations of the Work Unit Conservationist, the Soil Scientist and the Geologist. Gross erosion yield, delivery rates and

other pertinent data were estimated and recorded on the forms SCS-309. These estimates are considered adequate for design purposes. The drainage area above each proposed site was studied and reports prepared.

Field studies were made on the watershed flood plains to determine the extent of land damage due to erosion. These studies were carried out at the same time and in the same manner as those described under sedimentation investigations.

The data gathered in the course of this study indicated that scour damage is the only significant type of land damage in this watershed. These data were expanded to show location, extent of damage, and stage at which the damage occured. The resulting data form the basis for economic evaluations. Scour damage amounts to an estimated weighted average of 30% on 7.1 acres annually.

Economic Investigations

The basic information for agricultural type damages was obtained from personal interviews and questionnaires circulated to all the farmers within the flood plain. Approximately 95% of the farmers and farm operators were contacted to obtain information on crop production, crop damage and land use with the aid and cooperation of the local sponsoring organization. Non-agricultural damages were obtained from highway, railroad, and public utilities officials, and others connected with maintenance of these facilities.

All cost and prices used were based on 1963 price level. All damages, benefits, and operation and maintenance costs were converted to long term prices using "Agricultural Price and Cost Projections," September, 1957, published by the U. S. Department of Agriculture. Farm operation

costs were based on custom rates charged for power operated farm machinery, and other costs; such as seed, fertilizer and labor, obtained locally and converted to projected long-term prices.

A 3-1/8% interest rate was used for discounting future benefits and in converting public and private investment eligible for Federal loans to annual basis. A 5% rate was used in converting associated on-farm costs to annual basis. Evaluation of all project benefits were based on a 50 year period.

Land easement and rights-of-way cost estimates were arrived at by (1) measuring the area involved by each floodwater retarding structure as plotted on topographic maps; (2) estimating the area needed for channel improvement; (3) determining the per acre cost of the land involved as estimated by the local sponsors in consultation with the Service. These values were checked against the average net production per acre for this land under present conditions and use. There was little or no difference between this and the amortized acre cost that is included in the installation cost as land easements and rights-of-way.

Floodwater damages and benefits were computed using the frequency method as described in Chapter 3 of the Economic Guide, Soil Conservation Service. Separate damage frequency curves were developed for each reach and each type of damage using the stage frequency data provided in the hydrologic study.

The procedure used for intensive study of crop and pasture damage is based upon the damage resulting from the largest flood in each year, with a 20% adjustment factor to convert to the most damaging flood each

year. A 15% factor is added for recurrent damages from duplicate flooding of bottomlands.

Full valley cross-sections which were combined into damage reaches (also hydrologic reaches) were used in determining the acres flooded by depth increments of 0-2 and over 2 feet. From farmer interviews and general inspection, land use, yields, and cropping pattern for the flood plain were considered on one composite acre. No consistency in land use pattern was noted in relation to elevation along the flood plain.

Flood damage factors for each month and for two depth categories, 0-2 and over 2 feet, were determined for each crop. Damage schedules were developed, by months, for the different crops and weighted by the percent of monthly rainfall distribution. An average annual damage figure per acre for the two depth categories was computed for the composite acre.

The composite acre and flood free yields used are as follows:

Without Project	Crop	Yield/Acre	Percent
	Corn	90 bu.	58.0
	Soybeans	25 bu.	8.5
	Wheat	30 bu.	2.5
	Meadow	3 ton	2.7
	Perm. Pasture	75 C.P.D.	3.6
	Green Beans	2.5 ton	0.5
	Cabbage	16 ton	0.5
	Other	-	23.7

The average annual damage figure per acre, based on the above composite acres for depth 0-2 feet and over 2 feet, was used to develop

a stage damage curve for each reach. From peak discharge-frequency relationship, a flood damage versus frequency of occurrence graph was made. The average annual crop and pasture damage for each reach was then determined by planimetering the area under the curve and converting to dollar damage according to the scale of the graph.

The average annual benefit, by reaches, due to works of improvement, was determined by subtracting the remaining damages with the works of improvement from the damage evaluated without the measures.
Other agricultural damages were based on damage value per acre as determined from interview information. The amount of money spent for the removal of debris and fence repair was related to the area flooded for three frequency size floods; large (25 to 50 year flood); medium (10-15 year flood); and small (annual or two-year flood). The area flooded by each of these floods was available from crop and pasture damage studies for each reach.

The average annual damage and benefit for each reach was determined from its respective damage versus frequency curve as explained above for crop and pasture.

Non-agricultural damages to roads and bridges, including railroad, were obtained from highway and railroad officials and maintenance crews as to the amount of damage at different depths and sizes of flood. Using information from the Hydrologist, these occurrences were grouped as to frequency. The monetary value of damages due to a large flood--25 to 50 year, medium size flood--10 to 15 year, and the stage at which damage begins, was obtained for each significant damage location in a reach. A damage versus frequency curve was developed. The stage and frequency at

which no flood damage occurs and the frequency and stage of the medium and large size floods was determined by the Hydrologist based on cross-sectional data at or near the point of damage.

The monetary value of the average annual damage to roads and bridges was obtained by use of the damage versus frequency curve for with and without the proposed works of improvement. Average annual benefit was derived by subtracting the remaining damages from the damage evaluated without the measure.

Urban damage to the Town of Borden was based on the Corps of Engineers' survey made of the June 13, 1960 flood at Borden. Two synthetic floods, one, two feet higher and the other two feet lower than the June 13 flood were used to construct a stage damage curve. The estimate of the two synthetic floods was adjusted after general inspection of the area and to account for new improvements and other changes that have taken place since this survey was made.

This damage curve was tied in with the stages and evaluated at valley section ID55, located near the west end of the Borden Cabinet Factory. A stage damage versus frequency curve for with and without the proposed works of improvement was developed. Average annual benefit was derived by subtracting the remaining damages from the damage evaluated without the measures.

Estimates of erosion damage in the way of flood plain scour were developed by, (1) composite acre value of land being damaged, (2) annual increment of damage, (3) percent reduction in productivity, and (4) expected recovery. The formula used for converting to monetary terms is outlined in the Engineering and Watershed Planning Unit October 1954

Training Outline, Flood Plain Scour, III-A-2-c-(4), page 118. The reduction of damage was computed as a 100% reduction on that part of the flood plain no longer flooding after installation of project.

Indirect damages were estimated to be ten percent of the total agricultural and non-agricultural damage.

Determination of Annual Benefits from Changed Land Use and More Intensive Use of Present Cropland

Benefits due to more intensive use of present cropland within the flood plain were determined from basic field data obtained from farmer interviews and professional agricultural leaders. This information was used to determine the level of production expected with adequate internal drainage, a stable water table and a moderately high level of fertility and management program that could be expected with the level of protection proposed by this project.

In determining the number of acres that will be farmed at a more intensive use due to reduced flooding, a tabular form was used showing the number of acres flooded at average of 2-year and 5-year frequencies for "without project" and "with project" conditions. This represents the range (3 to 5 year) protection generally required to bring about fertility practices and management that will result in added income from more intensive use of present cropland. The proposed measures will reduce the frequency of flooding on 2,267 acres on which a more intensive use benefit will be derived. Benefit to changed land use was estimated on 160 acres of woodland that will be cleared for cropland as determined by interview. This area will have a five year level of protection with project.

All production type benefits were determined by (1) the expected participation, (2) future net income, (3) deducting all associated costs, (4) discounting for lag in accrual, and (5) deducting future flood damage to a higher damageable crop.

Supporting Data - More Intensive Use of Present Cropland

Land Use	Acres	Flood Free Yield	Gross Value (Dollars)	Production Cost (Dollars)	Net Return (Dollars)
Without Project					
Corn	1,811	90 bu.	226,556	87,290	139,266
Soybeans	263	25 bu.	15,122	5,802	9,320
Wheat	75	30 bu.	3,488	2,113	1,375
Meadow	82	3 ton	4,674	3,272	1,402
Cabbage	18	16 ton	3,632	2,082	1,550
Green Beans	18	5 ton	5,063	3,115	1,948
TOTAL	2,267				154,861
With Project					
Corn	1,596	100 bu.	221,844	85,705	136,139
Soybeans	238	25 bu.	13,685	5,252	8,433
Wheat	77	32 bu.	3,819	2,296	1,523
Meadow	91	3 ton	5,187	3,631	1,556
Cabbage	88	20 ton	22,194	11,587	10,607
Green Beans	82	6 ton	27,680	15,545	12,135
Cucumbers	48	3.5 ton	17,925	4,955	12,970
Mellons	47	360 bu.	24,534	9,487	15,047
TOTAL	2,267				198,410
			Net difference		43,549

Less associated cost:

Tile dr. 438 acs x 600 ft/ac x .28/ft. x .06505 (30 yrs. @5%)= 4,787

Less damage to higher damageable value 4,530

Total Net Value 34,232

34,232 x .692 (discounted 20 yrs.@3-1/8%) x 78% participation = 18,477

Net Benefit 18,477

Supporting Data - Changed Land Use

200 acres woodland, 80% participation - 160 acres

Land Use	Acres	Flood Free Yield	Gross Value (Dollars)	Production Cost (Dollars)	Net Return (Dollars)
Corn	128	90 bu.	16,013	6,170	9,843
Soybeans	21	25 bu.	1,207	463	744
Wheat	5	30 bu.	232	141	91
Meadow	6	3 ton	342	239	103
TOTAL	160				10,781

Less associated cost:

Clearing $200 x 160 x .05478 (50 yrs. @ 5%)	1,750
Tile - Ave. 500'/ac. x .28 x 160 x .06505	1,450
Open dr. 2640 ft. x .045 x .05478	65
Less flood damage to higher values	385
	7,131
Average annual changed land use benefit discounted @ 3-1/8% 20 yrs. 7,131 x .692 =	4,935

Secondary benefits were evaluated on the following basis: (1) value of local secondary benefits stemming from the project were considered to equal 10% of the direct primary benefits less indirect benefits, (2) secondary benefits induced by the project were considered to equal 10% of the increased cost incurred in connection with increased production.

Recreation benefits to the three multiple purpose structures were determined on the basis of visitor-day of use. Information as to the estimated visitor-days of use was furnished by the local people and

checked by interviews of operators of similar, existing recreational facilities in the local area. Data used by the Indiana Flood Control and Water Resources Commission for determining recreation benefits to the recreational development on Deams Lake were also studied. The total estimated visitor-day of use to the three structures is 17,400 annually. A value of $1.00 per visitor-day was used, making a total recreational benefit of $17,400.

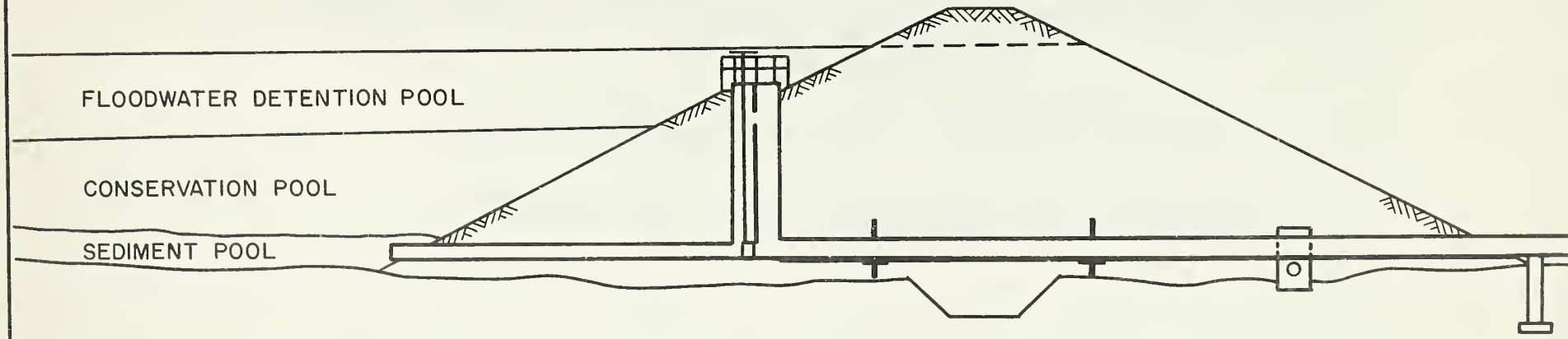
Municipal water supply benefits were determined by W. George Keat and Associates, Consulting Engineers, Louisville, Kentucky.

Evaluation of redevelopment benefits, resulting from income provided to the unemployed and under-employed labor of the area, is based on local labor used in project construction of the structural measures, in future operation and maintenance of the measures, and in filling new positions created as a result of the project.

Interviews with local business leaders formed the basis for estimating the number of new positions to be created.

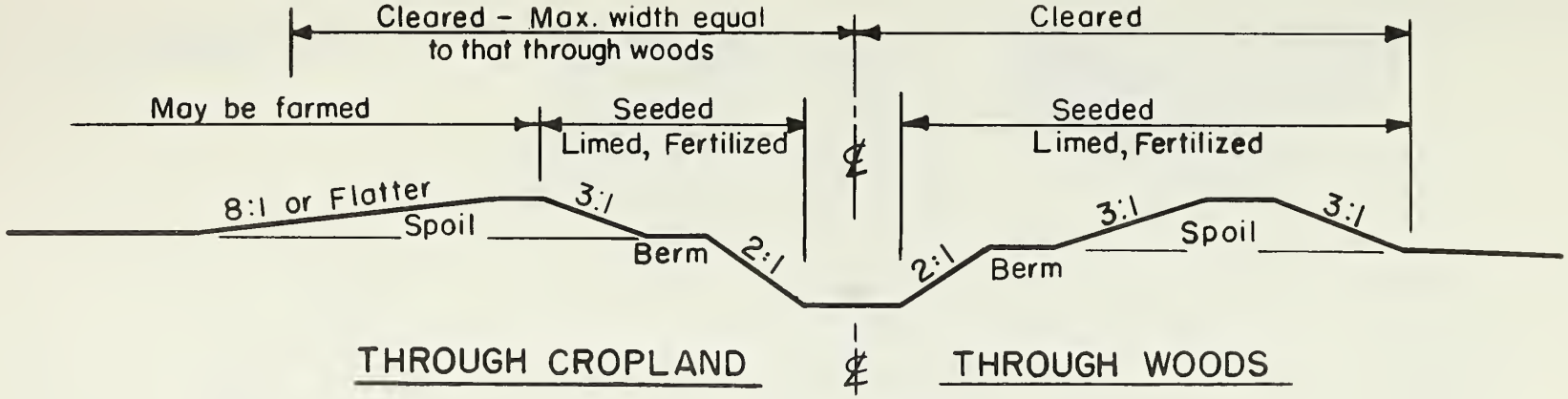
The average annual equivalent benefit was determined by amortizing the total benefit over the project life. The total benefit equals the wages paid to the local labor used in construction plus the wages paid to the local labor for operation and maintenance of the project measures, and for filling new positions created by the project, for the next twenty years reduced to their present value.

The labor used in construction was based on current rates, whereas, labor used in operation and maintenance and filling new positions was based on projected long term rates.

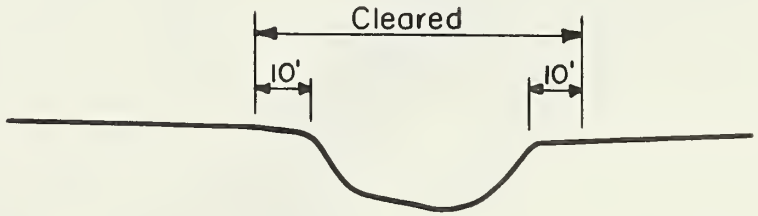


SECTION OF A TYPICAL
MULTIPLE PURPOSE STRUCTURE

Figure 1



TYPICAL SECTION - CHANNEL ENLARGEMENT



TYPICAL SECTION - CLEARING AND SNAGGING

STATION 1036+00 TO 1065+50

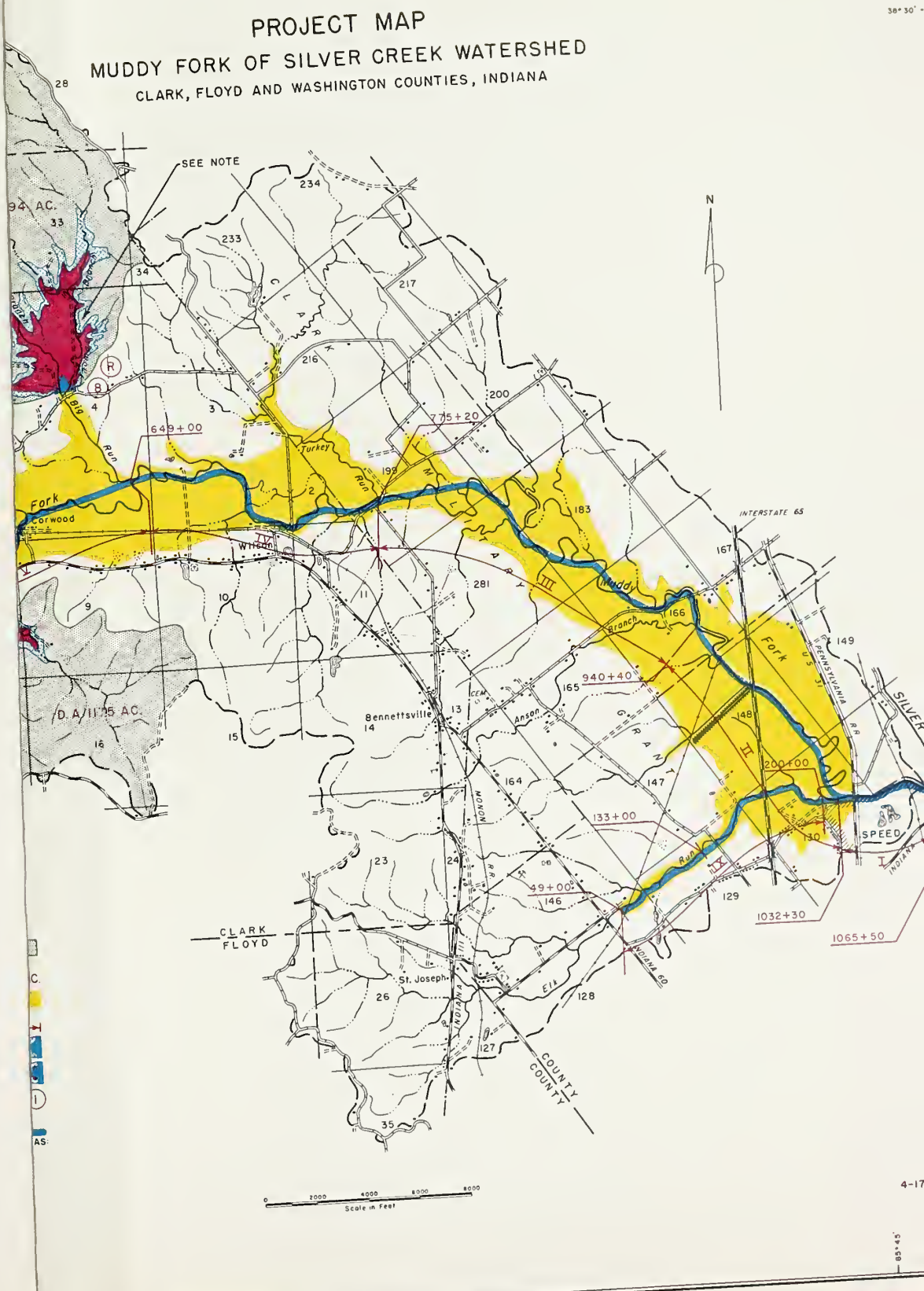
Figure 2

USDA SCS MILWAUKEE WIS 1964

PROJECT MAP

MUDDY FORK OF SILVER CREEK WATERSHED

CLARK, FLOYD AND WASHINGTON COUNTIES, INDIANA



U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

PROJECT MAP

MUDDY FORK OF SILVER CREEK WATERSHED

CLARK, FLOYD AND WASHINGTON COUNTIES, INDIANA

R 5 E | R 6 E

T 1 N
T 1 S

D.A. 1284 AC.
D.A. 2040 AC.
D.A. 2769 AC.
D.A. 2394 AC.
D.A. 2456 AC.
D.A. 1536 AC.
D.A. 1663 AC.
D.A. 1175 AC.

SEE NOTE

BORDEN
Bloom Hill
Bennettsville
St. Joseph
SPEED

WASHINGTON COUNTY
CLARK COUNTY
FLOYD COUNTY

Muddy Fork
Silver Creek
Fork

INTERSTATE 65

251+00
342+00
413+00
467+00
535+00
640+00
735+20
940+40
1032+30
1065+50
133+00
39+00
200+00

N

INDIANA

LOCATION IN INDIANA

LEGEND

- COUNTY LINE
- CLARK MILITARY GRANT BOUNDARY
- CIVIL TOWNSHIP LINE
- U S TOWNSHIP LINE
- SECTION LINE
- SUPER HIGHWAY
- PAVED ROAD
- GRAVEL ROAD
- DIRT ROAD
- FARM OR UNIMPROVED ROAD
- RAILROAD
- CROSSING (GRADE)
- BRIDGE (ROAD)
- HOUSE
- SCHOOL
- CHURCH
- CEMETERY
- CITY
- PERENNIAL STREAM
- INTERMITTENT STREAM
- STREAM DISAPPEARS ON FLAT
- PERENNIAL LAKE OR POND
- POWER LINE
- GRAVEL PIT, QUARRY OR MINE
- WATERSHED BOUNDARY
- LEVEE
- 12 FOOT MERR

- DRAINAGE AREA CONTROLLED BY STRUCTURE
- DRAINAGE AREA ACREAGE ..... D.A. 2040 AC
- AREA BENEFITED
- REACHES
- FLOODWATER RETARDING STRUCTURE
- MULTIPLE PURPOSE STRUCTURE
- STRUCTURE NUMBER
- CHANNEL IMPROVEMENT FOR FLOOD PREVENTION
- LETTERS INDICATE PURPOSE OF WATER SUPPLY SUCH AS
- (M) ... MUNICIPAL
- (R) ... RECREATION

NOTE: STRUCTURE NUMBER 8 WILL BE BUILT BY THE INDIANA FLOOD CONTROL AND WATER RESOURCES COMMISSION. STATE OF INDIANA 55% FUNDS

4-17-64.

USDA SCS MILWAUKEE WIS 1964

APPENDIX

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

WORK PLAN FOR FORESTRY PROGRAM

ON

MUDDY FORK OF SILVER CREEK WATERSHED

CLARK, WASHINGTON, AND FLOYD COUNTIES, INDIANA

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

WORK PLAN FOR FORESTRY PROGRAM

ON

MUDDY FORK OF SILVER CREEK WATERSHED

CLARK, WASHINGTON, AND FLOYD COUNTIES, INDIANA

JUNE, 1963

I. Introduction

This work plan for the Forestry Program of the Muddy Fork of Silver Creek Watershed describes the procedures used in developing the data and lists the forestry measures that will contribute to watershed protection and flood prevention.

II. Procedure

Woodland locations for the watershed are shown on the U. S. Geological Service quadrangle from which a grid count was made to determine woodland area.

Using random sampling techniques, 40 woodland study areas were selected for examination. On these, 240 separate measurements of hydrologic condition factors were taken.

Timber types, conditions and volumes were observed for each plot area. Past treatment and management needs were recorded. The data was summarized, analyzed, and developed through standard calculations into the proposed program.

Preliminary participation estimates of forest land treatment measures which may be attained during the installation period were arrived at in consultation with the state Watershed Forester and

the Woodland Conservationist and Area and Work Unit Conservationist, SCS, assisting the County Soil and Water Conservation Districts. Final decision on measures and amounts to be included in the work plan will eventually be determined in consultation with the watershed sponsoring organizations.

Land treatment measures on state-owned lands within the Clark State Forest which total not less than 3,740 acres were planned with the Watershed Forester. The forestry program and needs for technical assistance for this area are based on this plan and specific information furnished later to augment it.

III. Woodland Condition Summary

Woodlands comprise an estimated 68% of the watershed and are almost entirely upland, being located on the steeper slopes. Broadly classified, timber types are as follows:

Type	Acres	Percent
Oaks	14,579	50
Hardwood, mixed	9,330	32
Oak-Pine	3,790	13
Pine	1,458	5
Total	29,157	100

Stocking (overstory)	Acres	Percent
Well stocked	15,453	53
Moderately stocked	11,663	40
Poorly stocked	2,041	7
Total	29,157	100

Stocking (understory)	Acres	Percent
Well stocked	4,957	17
Moderately stocked	16,911	58
Poorly stocked	7,289	25
Total	29,157	100

Merchantable Volume Average Net MBF Per Acre	Acres	Percent
0-2	14,578	50
3-5	10,205	35
6+	4,374	15
Total	29,157	100

Timber harvest during the last ten years has been very light. The stands, being largely on steep slopes, are difficult to log. Until the volume which can be cut is sufficient to justify costs, logging will not be undertaken. Many areas which were once logged now contain young stands which have not reached merchantable size.

In the past, fire has caused the greatest damage in the watershed. Since fire protection has become effective, reproduction in the stands is bringing them back to full stocking. Shortleaf pine is also restocking naturally in many areas. Areas which once showed evidence of erosion are now restocking satisfactorily. State forest lands are generally well stocked and are considered as being under satisfactory management.

Grazing use is very limited. It is presently confined almost entirely to limited fringe areas of farms on the watershed perimeter or along the lower hillsides on some farms in the lower valleys. Grazing was apparently never extensive in the area due to the steepness of the woodland terrain and inability of settlers to penetrate many of the stream branches. Present trends in livestock production further discourage woodland grazing. The survey indicates that not over 5% of the woodlands are grazed.

No evidence of recent fire damage was seen. The watershed is being protected by the state under the Cooperative Fire Control Program.

IV. Needed Forestry Program for Watershed Protection

The total need for each practice under the forestry program reflects the present condition of the woodlands. To achieve maximum improvement of the hydrology of the woodland soils, it would be necessary to accomplish the entire needed job. During the five year installation period, a portion of this total need will be achieved. This five year goal is the immediate objective.

As both private and state lands are involved, they are listed separately. The total needs for forestry include:

Private Ownership

Practice	Acres*	Percent of Private Woodland
Fire Control Intensification	25,417	100
Livestock Exclusion	1,270	5
Improved Forestry Practices	24,657	97
Cultural Practices	4,829	19

* Some areas need a combination of these practices while other areas need none. A total of this column shows total acres of needed treatments only.

State Ownership

Practice	Acres	Percent of Private Woodland
Fire Control Intensification	3,740	100
Cultural Practices	2,240	60

The following described forestry measures are those recommended for use on P.L. 566 watershed work projects in the North Central Region. The primary purpose of these measures is to improve and maintain the hydrologic conditions of watershed woodlands. Installation of forestry measures will simultaneously result in improvement of the timber stand and enhancement of other basic values which are

inherent in a well managed forest. Additional measures may be prescribed and recommended to correct unusual situations on some projects.

WOODLAND IMPROVEMENT MEASURES

Fire Control Intensification (F)

This measure consists of prevention of woods fires and effective control of any fires that may start. The forester would try to obtain State fire control protection to woodlands in the watershed. If intensive fire protection cannot be provided by the State, he should go through proper channels to alert the local volunteer fire department to provide the fire protection needed. The objective is to hold the burned area to zero acres but at worst to no more than 1/10 of 1 percent a year.

Some measures included would be construction of Firebreaks, roads, and trails; lookout towers; installing fire tool caches and training wardens and fire crews. Fire prevention education programs may also be needed.

Fire destroys litter and humus as well as the trees. Water infiltration, retention and detention are reduced and runoff is increased. Young growth is damaged or destroyed, and this adversely affects the development and replenishment of litter and humus. Productivity of the woodland in turn is decreased and the quality of products is reduced.

Technical assistance is needed for informing and demonstrating the benefits of fire protection and prevention measures to woodland

owners. Assistance in locating personnel and equipment and in preparation of prevention materials may be required.

Livestock Exclusion (L)

This measure consists of excluding all farm livestock permanently from woodlands. To accomplish this may require fencing all or a part of the woodland. It also may be accomplished by a permanent change in use of adjacent agricultural land.

Grazing by livestock has a damaging effect on the hydrologic condition of the woodlands. The litter and humus layers are destroyed or compacted which greatly reduces their ability to absorb water and to retain and detain it. As a consequence, the amount of runoff is increased. In addition, grazing destroys young growth and reduces the density of the stand and thus impairs the development and replenishment of litter and humus. Damage to the young growth and mature trees reduces the productivity of the woodlands and the quality of forest products.

Technical assistance is needed to inform and demonstrate to woodland owners the effects of woodland grazing from the standpoint of low forage yield for livestock and damage to woodlands resulting in poor hydrologic condition and reduced economic value.

Improved Forestry Practices (M)

This measure, accomplished through proper management of woodlands, establishes a permanent forest cover adequately stocked with desirable species of suitable age classes.

In young stands a sustained yield management plan defines and schedules the improvement and protection measures needed to develop

a thrifty, fast growing woodland with good species. In woodlands having merchantable timber, proper harvesting of timber crops according to the best sustained yield practices will result in improvement and maintenance of an effective forest cover with good species composition, density, and age class conditions.

Use of proper logging methods and layout of roads in the woodlands with due regard to the topography and soil will help prevent harmful effects of the harvesting operation due to erosion and runoff.

These factors will assure maintenance and improvement of the hydrologic condition and of the productive capacity of the woodlands.

Technical assistance is needed for education and assistance in preparing woodland management plans, in marketing trees to be harvested, utilization and marketing of products, and the proper logging methods.

The following measures; sustained yield practices and cultural practices, are a part of the total of this practice.

Sustained Yield Practices (H)

This measure includes the preparation of Timber Harvesting plans including the marking, estimating and timber sale contract assistance. Help in locating logging roads, landings and portable mill sites to reduce soil and Hydrologic condition damages and other activities in connection with the harvesting of woodlands are included.

Cultural Practices (C)

This practice consists of the conventional timber stand improvement measures and reinforcement planting with special emphasis on improving the hydrologic condition of the woodland. Diseased, defective, poorly formed and otherwise undesirable trees are eliminated from the stand by cutting, poisoning or girdling to improve species composition, stand density and rate of growth. At the same time it is improtant to maintain the proper level of stocking. This is accomplished with stand conversion or reinforcement planting.

Timber stand improvement will increase yields and produce higher quality products. It will help to insure that the land will remain in woodland, be managed and protected, thus contributing needed hydrologic benefits.

The stand conversion practice consists of planting trees in openings of thinly stocked woodlands to bring them to the proper stocking level and to improve their composition and hydrologic characteristics. A fully stocked stand of desirable tree species is the objective.

Technical assistance is needed to determine the needs of various woodlands for treatment, type of treatment needed, and methods to be used, as well as for demonstration pruposes in marking trees which should be removed. Assistance in selecting tree species and planting methods would be included.

Forestation (P)

This measure consists of planting suitable species of trees on open land for the establishment of a forest stand. Planting is

recommended for land better suited to woodland than to agriculture, that is, land with steep topography, depleted fertility, presence of rocks, brush, erosion, or other factors.

The purpose of the measure is to improve hydrologic condition by the establishment of a forest cover, and achieve better land use. This will build up litter and humus and create conditions which will contribute to better infiltration, retention, and detention capacity, reduced runoff and soil stabilization.

Technical assistance is needed to help the landowner select areas to be planted and species and methods to be used in planting.

V. Planned Program for Watershed Protection

The following table shows need and expected participation and accomplishment during the five year installation period. These estimates are based on the assumption that adequate technical assistance will be available to build and carry through an accelerated program and that a high level of cooperation will be shown by local groups and assisting agencies.

Forestry Practices	(1) Needed Program (acres)	(2) Estimated Participation (percent)	(3) Planned Program 5 years (acres)	(4) Est. Accomp. By Going Project 5 years (acres)	(5) Balance for Watershed Project-5 yr. (acres)
		PRIVATE LANDS			
Fire Protection F*	25,417	100	25,417	25,417	-
Livestock Exclusion L*	1,270	30	380	-	380
Improved Forestry Practices M*	24,657	50	12,330	-	12,330
Cultural Practices C*	4,829	25	1,200	-	1,200
		STATE LANDS			
Fire Control Intensification F*	3,740	100	3,740	3,740	--
Improved Forestry Practices M*	3,740	100	3,740	3,740	--
Cultural Practices C*	2,240	45	1,000	--	1,000

* Letter designation used in tables

Column (1) is based on needs as determined by field observations.

Columns (2), (3), and (4) totals were determined in consultations with local Soil Conservation Service personnel and foresters representing the Indiana Department of Conservation, Division of Forestry.

Column (5) totals show the accomplishment planned for the five year installation period under the accelerated PL-566 program.

Project Installation

"Technical assistance for the forestry measures will be furnished by the Indiana Department of Conservation, Division of Forestry, in cooperation with the U. S. Forest Service."

Financing Project Installation

"Table 1 shows the area of land programmed for treatment and the cost of technical assistance for forestry to be furnished by the Indiana Department of Conservation, Division of Forestry, in cooperation with the U. S. Forest Service. The technical assistance for installing forestry measures will cost $34,240.00 of which $15,690 will be provided under authority of PL-566 and $14,810.00 will be provided by the Indiana Department of Conservation, Division of Forestry. In addition, the Indiana Department of Conservation will provide $3,740 for technical assistance under the Cooperative Forest Management program."

Provisions for Operation and Maintenance

"Program measures after completion of the PL-566 project will be maintained by landowners and operators with technical assistance provided by the Indiana Department of Conservation, Division of Forestry,

in cooperation with the U. S. Forest Service under the going Cooperative Forest Management program."

VI. Hydrologic Significance

The woodland soils in this watershed are in Hydrologic Soil Group D, which is that group having very low infiltration rates after being thoroughly wetted.

The present hydrologic condition class is 3.1 with a corresponding runoff/precipitation curve No. 79.

Installation of the measures programmed above will bring the average future hydrologic condition during the next 50 years to a class of 3.6 with a corresponding runoff/precipitation curve No. 75. This is a fair to average hydrologic condition.

VII. Cost of Program Installation

Unit costs are based on State and local averages for similar work, with adjustments for an accelerated program.

Practices to be Applied			Estimated Costs					
Practice			PL-566 Techn. Assistance		Other Costs - Technical Assistance & Installation			Total Costs
	Non-Fed. Acres	Fed. Acres	Non-Fed. Land $	Fed. Land $	Cost $ per Acre	Non-Fed. Land $	Fed. Land $	
F	29,157				.20	5,830		5,830
L	380				6.00	2,280		2.280
M	16,070				1.00	16,070		16,070
C	2,200				12.00	26,400		26,400
Technical Assistance			15,690 3/		1.84 4/	3,740 1/ 14,810 3/		3,740 30,500
Total	18,650 5/		15,690			69,130		84,820

1/ Cost of State and Federal Cooperative Forest Management for going program technical assistance costs.

2/ Federal PL-566 technical assistance funds for use in matching State funds. Includes 25 percent increase for overhead.

3/ State technical assistance funds for use in matching Federal PL-566 funds. Includes 18 percent increase for overhead.

4/ Average technical assistance cost per acre based on all items except F.

5/ Total acres of practices programmed excluding item F.

Cooperative Watershed Management Branch
Division of State and Private Forestry
U. S. Forest Service
North Central Region